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WAGES AND WORK

Resolutions which were passed at the annual conference last week of the Confederation of Shipbuilding and Engineering Unions must be regarded as a "curtain raiser" for further negotiations on the subject of wages and working hours. There were three decisions of far-reaching importance taken at the conference. Delegates representing the thirty-nine unions comprising the Confederation instructed the executive council to formulate a claim for a "substantial increase in wages," to press for a forty-hour week without reduction of pay, and to press also for three weeks' annual holiday, with payment for it calculated on average earnings instead of on basic weekly rates. In the absence of particulars as to the actual amount of the "substantial" wage increase mentioned, it is, of course, impossible to make any assessment of the cost to the engineering and shipbuilding industries if these proposals were to be fully implemented. When they are presented in their detailed form they will, without doubt, be carefully examined. What, it seems to us, is desirable just now is to keep clearly in view the damaging effect upon the national economy of any steps likely to increase costs in industries that are facing growing competition from other countries.

In his presidential address at last week's conference, Mr. Brotherton spoke about the "profits boom," in which, he claimed, engineering employers had shared to the full. He also mentioned the increased productivity in the engineering industry which, he maintained, had added "very substantially to the profits of the employers." Rising productivity and profits, Mr. Brotherton suggested, automatically generated a demand for improved conditions of employment, and on that basis he urged that claims—meaning, we presume, wage claims—were justified. On the face of things, Mr. Brotherton's argument is sound enough. It is one that the large majority of engineering employers would endorse, and there has been plenty of evidence in recent years of the increasing participation of the employees in the prosperity of the engineering and shipbuilding industries. In nearly all the post-war years wage increases have been granted, the latest award having been made as recently as last March. Then, additions were made, to the basic weekly rates, of 11s. for skilled men, 9s. 6d. for the intermediate grades, and 8s. for unskilled men. In intimating that engineering employers were willing to make those increases, a spokesman of the Engineering and Allied Employers National Federation pointed out that the upward trend in profits had enabled employers to discuss how the people who had contributed to the improvement could benefit from it. The prosperity of the industry, he emphasised, was a joint affair. At the same time, the Federation quite rightly stressed the fact that it could not regard with indifference the rising competitive power of other countries, as well as the policy of so many countries to establish their own industries. Those are considerations which must still be kept constantly in mind. Were the engineering industry of this country to ignore them, its prosperity curve would quickly begin to show a downward trend.

Very little appears to have been said about these matters at last week's conference of union representatives. Yet another "warning" about the way things are going has been given as this issue goes to press. In its monthly review of the economic situation, the Treasury has once again pointed out that the two main threats to British competitive power in world markets are excessive home demand, absorbing goods that should be exported, and money incomes growing faster than output, causing costs, and therefore prices, to rise. This statement is elaborated by figures showing labour costs in different sectors of the economy in the period 1948 to 1954. The Treasury acknowledges that these figures "are subject to wide and varying margins of error and must be

treated cautiously." The conclusion reached from them, however, is that, in the six-year period, labour costs per unit of output in the economy as a whole have risen by about 27 per cent, and in the manufacturing industries by about 20 per cent, the whole of this latter increase having occurred in the last two years. It has to be recognised that it is becoming more difficult every day for the British engineering industry to keep its place in the markets of the world. A survey of engineering exports, made recently by the British Engineers' Association, shows that although last year the value of the United Kingdom's engineering exports was higher than in 1953, the addition was a modest one. The total fell below that of 1952. On the other hand, the export trade of Western Germany has progressively increased. The conclusion reached, therefore, in this survey is that "if engineering exports from the United Kingdom and from Western Germany continue this year to move as they have done in the recent past, it may be that in 1955 the lead which the United Kingdom has held since the end of the war will be further diminished." That is not just a gloomy prophecy; it is a realist viewpoint. It again underlines the fact that the prosperity of the engineering industry is a "joint affair." There is no question about the continuing high quality of British engineering products. But the question of the right price becomes ever more important. The projected demands of the unions for higher basic wages and shorter hours will inevitably hinder progress towards more competitive prices in overseas markets. Our overseas payments account shows that there is too much "running into the red." It is folly to do nothing more than to go on hoping for an improvement. In all industries, and in the engineering industry in particular, in view of its prominent place in our export trade, wages must keep in step with output. At this stage, surely, higher wages must be the result of more work, not less!

GROUND-TO-AIR] DEFENCE

In a recent debate in Parliament on the ground-to-air defences of the United Kingdom, the Government's decision to abolish the Anti-Aircraft Command was criticised on the ground that there is nothing to take its place. Criticisms of this nature have no sound basis, for the abolition of the Anti-Aircraft Command Structure is the logical sequence of the development of nuclear weapons and of the high flying supersonic bomber. With bombers flying at 60,000ft it would be absurd to continue spending money and manpower on anti-aircraft guns with a maximum range in the region of 35,000ft, whether or not another defence system is available to replace them. This year's Defence White Paper, in fact, makes it clear that the air defence system of the United Kingdom is in future to be based on the manned fighter and the ground-to-air guided missile. But when is this new system to be introduced? It is over two years since the Air Officer Commanding-in-Chief, Fighter Command, announced that the future role of the guided missile in the air defence of this country "is now being planned" and, after this lapse of time, Members of Parliament are not unnaturally anxious to know whether a plan has yet materialised. The guided missile is being developed in Britain behind a veil of quite unnecessary secrecy and the nation has no idea what progress has been made or to what extent the missile can be relied on to assist Britain—a vital base of operations—to survive in a war which would be "a struggle for survival of the grimmest kind." This is the more regrettable in that the Americans have not only decided on a plan—and they make no secret of it—but they are putting it into effect by erecting an outer ring of anti-aircraft batteries of guided missiles, manned by Regular Army personnel, around their major cities, in support of their distant defence of large numbers of interceptor fighters.

Government spokesmen suggest that it is misleading to compare our position with the United States. Our object is, by a combination of guided weapons and manned fighters, to try and bring down bombers well out to sea—as far away as possible from our closely concentrated centres of industry and population. But why is this not practicable with the guided missiles now available if the guided missile batteries are installed in positions along our coasts? The range of the American ground-to-air "Nike" missile is about 25 miles and a similar but slightly larger missile with a range of 50 miles will soon be in production. There should be little damage from a nuclear explosion following the destruction of a bomber over 25 miles out to sea. The fact that we do not have to provide for Continental defence, as is necessary in the United States, should make our air defence problem easier, particularly with our very efficient radar warning system interlocked with the radar system in the Western European countries. It may well be that our Chiefs of Staff are not satisfied with the present performance of the ground-to-air missile—whether developed in this country or in the United States—and are not prepared to advise its production, or its purchase from the United States, on a large scale. If so the Government should make it clear that there has been a profound change in expert opinion during the past two years. In 1953, it will be remembered, both our own Minister of Supply and the Chief of Staff of the United States Army expressed complete confidence in the effectiveness and reliability of the guided missile. "No bomber," the Minister said, "could hope to out-manœuvre the guided missile under development in this country." And this view was confirmed by General Collins who assured his countrymen in the United States that the "Nike" could be relied on to bring down a bomber at 60,000ft. In any event suggestions that our needs are different from United States needs or that the Americans are richer or that they started earlier are not convincing reasons for this country's lack of progress in guided missile production.

While the Americans are spending hundreds of millions of pounds in manufacturing guided missiles in quantity and are erecting batteries for firing them, while they have armed their Air Force fighters and the naval fighter squadrons operating from nine of their carriers with air-to-air guided missiles, Britain's first operational surface-to-air missile has yet to be tested next year and production orders for air-to-air missiles have only recently been issued. The layman finds if difficult to understand the position and inevitably wonders whether it does not result from the present policy of giving priority to the production of a large force of V-bombers to add to the already immense strength of the United States Strategic Air Force. Can this country, indeed, afford a large force of V-bombers each costing some £500,000 and at the same time an adequate supply of very costly guided missiles? It is relevant also to bear in mind that our ground-to-air guided missile defence will require an immense and elaborate organisation—akin to that developed with so much enthusiasm by the Anti-Aircraft Command during the war—for which the Royal Air Force are now entirely responsible. Having regard to the priority function of the Air Force—to act as a deterrent and a counter-offensive force—will they be able to devote to this organisation the necessary resources and enthusiasm and the officers and technicians in the number and of the calibre required?

Centenarians

In an article entitled "Centenarians," in our issue of August 12th, we mentioned that a special Centenary Number would be issued to mark the event of the Centenary of this journal on January 4th next year. We would like to include in that Number a list of British manufacturing or consulting firms, institutions and societies, and journals, operating in the engineering, iron and steel, shipbuilding and other fields with which this journal is associated, that will have celebrated their Centenaries by January 4, 1956. Will each such firm, institution or journal please inform us about the date of its foundation, its title at that time and its present title? The information should be sent to The Editor, THE ENGINEER, 28, Essex Street, London, W.C.2, not later than September 5th next.

A Seven Day Journal

Cæsium Atom Standard of Time

THE building of an atomic time standard, based on the natural vibration period of the cæsium atom, means that the National Physical Laboratory now has a standard that is far more constant than astronomical time. Hitherto the working standard of time has been the quartz clock (using the rapid vibrations of a ring of quartz) adjusted periodically to keep in step with time as given by the rotation of the earth. But because the earth's rotational speed fluctuates slightly, this method of measuring time has been found to be insufficiently accurate for some scientific work. The cæsium standard, on the other hand, is said to be accurate to within one second in thirty years and the N.P.L. hopes that refinements in the apparatus will, in due course, limit the error to one second in 300 years. The method depends upon a distinctive magnetic property of certain atoms, of which cæsium is the most convenient. If the cæsium atom is placed in a rapidly alternating magnetic field and if the frequency corresponds exactly to a fundamental constant of the cæsium atom, then the atom will be made to change its magnetic state. According to the most accurate measurements so far made the required frequency is given as 9,192,631,830 c/s, but this figure is provisional. However, although the ultimate accuracy may not be known exactly, and although the existing apparatus is capable of simplification, the method is established. Cæsium atoms are evaporated from an oven at one end of a 5ft long copper tube supported on pedestals at each end. The cæsium atoms in this tube are subjected to an alternating magnetic field produced from a small transmitter, using radar techniques. At the other end of the tube the cæsium atoms are focused on a detector. If the frequency of the transmitter is set to exactly the right value the cæsium atoms will " reverse " and will be deflected away from the detector ; thus the attainment of the right frequency will be determined by an instantaneous drop in the number of atoms received at the detector. In this way the transmitter can be set at the characteristic cæsium frequency and can then be used to calibrate the quartz clock. The development by the N.P.L. of the cæsium standard as an improved means of calibrating quartz clocks is based on pioneer work on atomic standards of time carried out in America at Columbia University, the National Bureau of Standards and the Massachusetts Institute of Technology.

Aerial Survey of the Midlands

THE method of geophysical surveying by airborne magnetometers gives information of general scientific interest, more particularly relating to the magnetisation of rocks. It is not yet certain if the geological and economic results would justify the use of this method of surveying in a country such as Britain, where a great deal of geological information has already been obtained by other methods of surveying supplemented by boring. An airborne magnetometer survey might, however, provide information about the deeper-lying strata. On the recommendation of the D.S.I.R. the Nuffield Foundation has decided to pay for a pilot aeromagnetic survey to find out if the extensive use of such surveys in Great Britain would be worth while. The area selected for the survey is of 11,000 square miles within the boundary of Stockport, Market Rasen (Lincolnshire), Luton and Gloucester. It includes a variety of flat and hilly country and a wide range of geological problems ; it has been wholly surveyed by gravity meter and partly by ground magnetometer, and is included in the Geological Survey's programme of deep boring. The magnetometer equipment is towed below the aircraft on a non-magnetic cable while flying to and fro at over 1000ft, keeping a constant height either above sea level or above the ground below. The strips surveyed will be photographed at the same time. Test flying has taken place; the survey proper should be completed by early autumn and calculations and maps made by the end of the year.

Annual Report of Glasgow's Water Department

THE annual report of the chief engineer and manager of Glasgow Corporation's Water Department has just been published ; it deals with the period from June 1, 1954, to May 31, 1955. The event of the year was the celebration of the undertaking's centenary of the passing of the Act of 1855, authorising the Corporation to take over the then existing three water companies, build the Loch Katrine works, and, from that date, be responsible for the municipal water supply. Municipal history has shown how expeditiously and efficiently this was carried out and maintained, the report comments. To-day, the undertaking is unsurpassed, it is claimed, in its prime function of supplying an adequate, dependable and wholesome water supply to its 1¼ million consumers. The supply is also claimed to be of outstanding natural purity and cheapness with no record of any serious emergency or breakdown in its history. All the original works constructed since the year 1855 have continued to be in constant service. Amongst new works in progress during the year, the River Clyde water tunnel made steady progress. The Glen Finglas contract was let and the works commenced, and the West Main works, delayed by the uncertainty associated with the proposed vehicular tunnel, were nearing completion. Also during the year the last instalment of the original Loch Katrine scheme, commenced in the year 1855, was brought into use by the completion of the 48in diameter steel siphon pipelines across the Endrick and Blane valleys. These now enable the two aqueduct tunnels from Loch Katrine to Milngavie to discharge to full capacities. Castlemilk pumping station, which has the largest installed horsepower of the twelve pumping stations in use, was nearly completed, as were service reservoirs at Castlemilk and King's Park, Garthamlock pumping station, with its service reservoir, and Drumchapel water tower. The daily average consumption was 90·24 m.g.d. for all purposes, an increase of 2·8 m.g.d. over the previous year.

F.B.I. Overseas Scholarships

THE Federation of British Industries has published the annual report of its overseas scholarships scheme for the year ended March 31st last. This report shows that the scheme, which provides practical training in Britain for specially selected young graduate engineers from developing countries overseas, is expanding rapidly. Between the end of 1950, when the scheme began, and the end of the period reviewed, eighty scholarships had been awarded, sixty-four scholars had actually arrived in this country, and of that number twenty-three had already completed their training and returned home. Since the date of the report, the F.B.I. says, a further six scholars have arrived and forty-four more are expected by the end of the year. It is hoped that within a short time it will be possible to award 150 scholarships each year, and 107 are in fact now being offered for award during 1956. The countries from which scholars had come up to the end of March last were Argentina, Australia, Chile, Colombia, Cuba, India, Iran, Mexico, Pakistan, Peru, the Sudan and Uruguay ; since then scholarships have also been awarded in Brazil, Iraq, Ceylon, Malaya and Rhodesia, and are being offered in a number of other countries. The scholarships, it will be recalled, are at once a form of technical assistance to the countries concerned and a means of familiarising their future leaders of industry with British equipment and methods, so that they may be predisposed to " buy British." As the report says, they represent " a long-term investment in our future exports." The normal scholarship provides training for two years in a British engineering works, though provision is also made for shorter periods of specialised training. The present report includes an announcement about a new class of scholarship, to be administered jointly by the F.B.I. and the British Council, for young university professors from Latin America. This scholarship will cover a period of twenty months in this country, equally divided between an engineering works and a university. It is hoped that on their return these professors will arouse interest in British engineering achievements among their pupils and a desire for training in Britain. The cost of the normal scholarships, which may be as much as £1000 each, is met partly by contributions from the engineering works which accept scholars for training and partly by a Government grant, with the F.B.I. itself providing the administrative staff and meeting certain overhead expenses. The report includes a list of seventy-three firms or organisations already participating in the scheme.

Commonwealth Survey Officers' Conference

A COMMONWEALTH survey officers' conference, which is being held at Cambridge, was opened on Monday last, August 15th, and will continue until August 24th. The conference is discussing the considerable changes which have taken place in technical methods and organisations. The 250 delegates include contingents from Commonwealth and Colonial territories, observers from the U.S.A., Belgium, Holland and the Sudan, and representatives from many of this country's Government departments, particularly the Directorate of Colonial Surveys, Ordnance Survey Office, Directorate of Military Survey, Ministry of Supply, H.M. Land Registry, Admiralty, and National Physical Laboratory. Eighteen British manufacturers are participating in an exhibition of surveying instruments and equipment, and there is also an exhibition of photographs and mapping by various survey firms. Among the subjects covered in the twenty-six papers which are being read to the conference are : " Training of a Surveyor," " Radio Aids to Surveying," " Aerial Photography and Overseas Air Survey," " The Application of Electro-Mechanical Computing to the Work of the Ordnance Survey," " Electronic Aids to Hydrographic Surveying," and various aspects of survey work in Southern Rhodesia,

Nigeria, Uganda, North Borneo and Canada. When the conference ends visits are to be made to the Directorate of Military Surveys at Tolworth and the National Physical Laboratory on August 25th, and to the Directorate of Colonial Surveys, Tolworth, and Ordnance Survey Office, Chessington, on August 26th. Delegates are also visiting one of the latest naval survey ships, H.M.S. "Shackleton."

Coal and the Engineering Industry

THE Engineering Industries Association has circulated a statement setting out some suggestions for dealing with the difficulties caused to industry and to the national economy by the shortage of coal. The whole situation, the Association says, has been carefully examined by its financial problems committee. In the light of that committee's findings, the Association has put forward a nine-point plan which could, it is urged, be applied on a short-term as well as a long-term basis. Among the suggestions included in this plan, there is one that an Exchequer grant should be made to meet the cost of imported coal, and another that the membership of the National Coal Board should be strengthened by more part-time members with industrial experience and closer consultation with engineering. Yet another suggestion made in the plan is that better leadership should be secured at top levels within the National Coal Board's organisation. Then it is urged that mechanisation should be concentrated at pits where capital expenditure will be most quickly effective. The plan makes suggestions about recruitment, housing and apprenticeship schemes and about the employment of foreign miners. It goes on to recommend that the development of alternative sources of power should be expedited, that the National Industrial Fuel Efficiency Service should be expanded, and that the installation of fuel-saving equipment should be encouraged by 60 per cent tax investment allowances. In presenting this "plan," the Engineering Industries Association says that the level of production and high cost of coal must give rise to a series of national crises which are contributory to inflation and hamper export efforts. Unfortunately, the Association continues, there has been a tendency on the part of all concerned to relax into a state of complacency in between the periodical upheavals, be they price increases, wage demands or unsatisfactory production.

Obituary

SIR ALAN MOUNT, C.B.

WE record with regret the death of Lieutenant-Colonel Sir Alan Henry Lawrence Mount, which occurred in London on Wednesday of last week, August 10th. For thirty years he was an inspecting officer of railways at the Ministry of Transport, and for the greater part of that period, until his retirement in July, 1949, he held the position of chief inspecting officer. Sir Alan rendered distinguished service in that responsible post and during his period of office made noteworthy contributions to the high standard of safety in railway operation in this country.

Sir Alan, who was born at Welwyn, Herts, in 1881, was educated at Bradfield College and at Coopers Hill, and was commissioned in the Royal Engineers in 1902. He then spent some time at Chatham, and on the North-Western Railway in India, and throughout the first world war served in France as the deputy chief railway construction engineer. Sir Alan joined the Ministry of Transport as an inspecting officer of railways in 1919, and became chief inspecting officer in 1929. An important part of his duties was, of course, to inquire into and report upon railway accidents. In looking over the reports which bear his signature, it might at first be thought that the number of railway accidents investigated during Sir Alan's thirty years' service at the Ministry was considerable. Yet when the number of train movements is borne in mind, the high degree of operating safety is significant.

In reporting upon the major railway disasters which he investigated, Sir Alan never failed, in his "conclusions and recommendations," to put forward sound technical —and human—suggestions aimed at preventing the repetition of such accidents. His reports on several train accidents, for example, advocated the fuller development of automatic train control systems in this country. Then, in one report, that dealing with a derailment at Potters Bar in 1946, Sir Alan's suggestions led to the redesigning and rebuilding of the station, a project which has now been completed. In his annual reports as chief inspecting officer, Sir Alan revealed clearly his technical ability to expound problems associated with railway safety.

During his long and valuable service at the Ministry of Transport, Sir Alan was invited to head an investigation into the use of broad gauge "Pacific" locomotives in India. This investigation followed an accident at Bihia, on the East Indian Railway, in 1937. The Indian Government decided to appoint an independent expert committee to make this investigation, and Sir Alan was its chairman. In recognition of his services to this committee, Sir Alan received the honour of knighthood in 1941. He had previously received the honours of C.B.E. in 1919 and C.B. in 1931.

THOMAS LAWRIE, C.B.E.

MR. THOMAS LAWRIE, general manager of the North of Scotland Hydro-Electric Board, died suddenly in Edinburgh on Saturday, August 13th. He was born at Laurencekirk, Kincardineshire, on March 8, 1901, and was an M.A. of Cambridge, where he took the mechanical sciences tripos in 1923. He was a member of the Institution of Electrical Engineers, a member of the Institution of Mechanical Engineers, a fellow of the Royal Society of Edinburgh, and was awarded the C.B.E. in 1953.

Mr. Lawrie served an apprenticeship with the English Electric Company Ltd., at Stafford, and also worked in the shops at Monifieth Foundry, Dundee, and Fore River Shipyard, Boston, U.S.A. He was for three years in the hydro-electric section of the English Electric Company and later became secretary of the Power and Traction Finance Company, Ltd., which investigated and promoted electrification schemes in many parts of the world, including Belgrade, Budapest and Athens, and the Sudan Light and Power Company, which ran electricity and water supplies in Khartoum and Wad Medani.

He was concerned with the promotion of the Galloway Water Power Scheme and was secretary of the Galloway Water Power Company from 1931 to 1940. During the second world war, Mr. Lawrie was a Lieutenant-Commander in the R.N.V.R. and saw service at Dunkirk and Dieppe. He was released from the Services at the end of 1943 on the formation of the North of Scotland Hydro-Electric Board, to become its first secretary. In 1948 he became general manager. Among his many other interests in the electrical supply industry he was taking a very active part in developing pumped storage schemes.

F. G. PENNY

MR. FREDERICK GASTON PENNY, whose death occurred on August 6th at Derby, was well known in the engineering industry through his long association with International Combustion (Holdings), Ltd., and Aberdare Cables (Holdings), Ltd. He was managing director of the former company and chairman of the latter.

Mr. Penny, who was sixty-six when he died, was a native of Sale, Cheshire. He was educated at the Royal Salford Technical School and the Manchester College of Technology, and from 1904 to 1908 served an apprenticeship with George Richards and Co., Ltd., Broadheath. Thereafter, Mr. Penny gained additional works and drawing-office experience with the British Westinghouse Company, where he served for a period under the late Sir Holberry Mensforth. He then joined the staff of Willans and Robinson (later the English Electric Company, Ltd.) at Rugby, as an assistant mechanical engineer on turbine design, and subsequently held appointments with the Rotherham Corporation, as assistant electrical engineer, and with the Shanghai Electric Company, as generation engineer.

When he returned from Shanghai in 1926, Mr. Penny joined International Combustion, Ltd., as manager of the field staff. Later, he became chief engineer and general manager, and, in 1951, was appointed managing director. About the same time, Mr. Penny succeeded to the chairmanship of the associated company, Aberdare Cables (Holdings), Ltd. In addition, Mr. Penny served on the boards of several other engineering companies. To them all, he gave readily the benefit of the sound technical knowledge and business ability which he had acquired during his energetic and varied experience in the engineering industry. Mr. Penny was a member of the Institution of Civil Engineers and of the Institution of Mechanical Engineers.

SIR CHARLES BARTLETT

THE death occurred on August 10th of Sir Charles Bartlett at his home, near Harpenden, Herts, after an illness of many months. He was sixty-five. Sir Charles, though he began work in a bicycle shop at the age of twelve, intended to devote his life to horticulture, and after serving during the first world war with the Devonshire and Dorsetshire Regiments, it was the after-effects of a wound that compelled him to give up the outdoor life. He entered the British subsidiary of the General Motors Corporation as a book-keeper in 1921 and became managing director five years later.

When General Motors acquired Vauxhall Motors, Ltd., he became its managing director, and was chairman from June, 1953, until last December. His work over nearly thirty years with Vauxhall Motors, Ltd., was unsparingly devoted not narrowly to the firm but also to its workers, and the human problems of industry were a strong concern of his. In 1944 he was knighted in recognition of his own and his company's war effort. He was a Deputy Lieutenant of the County of Bedfordshire.

His early interest in gardens lasted throughout his life, joined with a liking for many sports.

Effect of Arcing on Air Flow Through Nozzle of a Gas Blast Circuit Breaker*

No. I

By A. A. HUDSON, B.Sc., Wh.Sc., D.I.C.

This article summarises investigations into the influence of the arc upon the air flow in the nozzle electrode of an axial-flow air blast circuit breaker. The mass flow of air through the nozzle during arcing and the static pressure at three points within it have been measured for a supply voltage of 3·8kV. The use of the mass flow ratio during arcing as a criterion in determining similar arc quenching conditions shows that this ratio may be expressed empirically as a function of the quantity $(I/d^{1\cdot5}p^{0\cdot5})$. *There is a critical range of this quantity in which a mixture of clearances and failures occur and which separates the region of clearances from that of failures. Regarding the centre of the critical range as the mean critical value of the ratio* $(I/d^{1\cdot5}p^{0\cdot5})$, *it is possible to correlate this quantity with switch and circuit variables other than I, d and p. So far, these include the rate of rise of restriking voltage and the distance between the nozzle and upstream electrodes (lower gap).*

(1) Introduction

THE study of the air flow, particularly in the presence of the arc, is clearly important in the problem of arc extinction under forced convection. The behaviour of an electric arc at any period of its history depends, amongst other things, on its interaction with its surroundings. Any study of what happens in these surroundings will therefore link up with, and indeed may contribute to, the general body of knowledge of arc phenomena.

Several attempts, mostly of a theoretical nature,[2–7] have been made to deal with this problem of air flow in circuit breakers, but the specific use of mass flow and its change in the presence of an arc, as a means of providing information whose emphasis is on phenomena external to the electrically conducting cross section of the arc column, does not appear to have been envisaged previously.

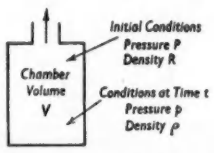


Fig. 1—Conditions in a chamber discharging air through an outlet nozzle

The basic idea underlying this work has been the assumption that, other quantities being constant, arc energies liberated in the breaker nozzle† which produce equal proportional changes in the mass of air flowing through the nozzle (irrespective of nozzle diameter or pressure) may be regarded as similar, as far as the factors which govern arc extinction are concerned. In the same way it follows that, for any nozzle diameter or pressure, similar arc energies produce equal proportional changes in the nozzle pressure.

The experimental investigation of flow conditions in the nozzle during the short circuit period is a problem of considerable difficulty, since the very high and rapidly varying temperature produced by the arc, renders both velocity and temperature measurements by normal methods impracticable. The mass flow of air, however, can be studied with comparative ease, since this can be determined from conditions existing in the flow at a point remote from the high-temperature region in the nozzle electrode.

The other quantity readily capable of experimental determination is the static pressure of the air flow, which may be measured by means of a hole at any required position in the nozzle wall.

The mass flow and the static pressure of the air flowing through the nozzle during the period of arcing, and their relationship to the breaker and circuit variables (namely, nozzle size, gaps, pressure, current, R.R.R.V.‡), have been studied experimentally and a number of interesting results have been obtained.

(2) Experimental Method of Measuring Mass Flow

(2.1) *Basis of the Measurement.*—Consider a reservoir filled with compressed air and capable of discharging the air through a nozzle into the atmosphere (see Fig. 1). Let

M = the mass of air in the reservoir at any instant.

p = mean pressure of air throughout the reservoir at the same instant.

γ = the ratio of the specific heats of air at constant pressure and at constant volume.

Under any conditions of flow in the nozzle, whether steady or otherwise, the rate of flow of air through the nozzle at any instant will equal the rate of change of the mass of air in the reservoir. Thus, the mass flow through the nozzle $= dM/dt$

$$= \text{Constant} \frac{1}{p^{(\gamma-1)/\gamma}} \frac{dp}{dt} \quad \text{(see Appendix)}$$

Thus, if the reservoir pressure and its rate of change can readily be measured, a convenient method is available for determining the variation of mass flow through the nozzle.

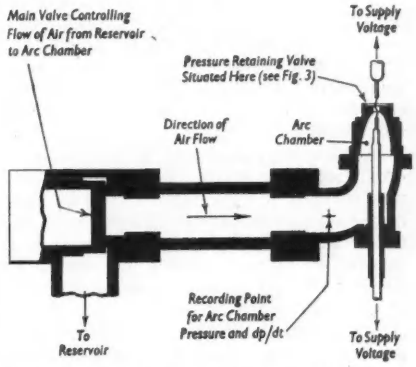

Main Valve Controlling Flow of Air from Reservoir to Arc Chamber
To Supply Voltage
Pressure Retaining Valve Situated Here (see Fig. 3)
Direction of Air Flow
Arc Chamber
Recording Point for Arc Chamber Pressure and dp/dt
To Reservoir
To Supply Voltage

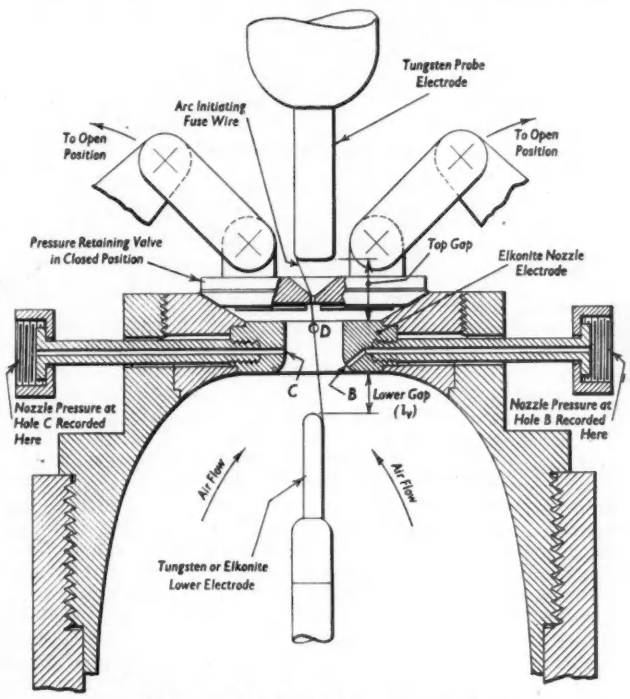
Fig. 3—Section through arc chamber used in the tests

(2.2) *Application of Method to the Circuit Breaker Problem.*—In applying the above expression to determine the mass flow from a chamber, two conditions must be fulfilled during the discharge period, namely,

(i) No air must be supplied to the chamber.

(ii) No heat must be added to or subtracted from the air, i.e. any changes take place adiabatically.

In the case of the flow from the arc chamber through the nozzle of an air blast circuit breaker, the first condition may be fulfilled quite easily, by ensuring that the main valve controlling the flow of air from the reservoir to the arc chamber is closed before arcing takes place in the nozzle. It would appear at first sight, however, that the second condition is not, in general, satisfied, owing to a source of heat formed in the arc chamber by the length of arc situated between the lower electrode and the nozzle. It may be shown, however, that, using the method described in paragraph (2.1), the true mass flow is given for all conditions except when a negative value is obtained, and then the true mass flow is negligibly small.



B, C and *D*, recording holes for the static pressure within the nozzle

Fig. 2—Electrode arrangement showing the nozzle pressure recording positions

(3) Test Procedure and Apparatus

(3.1) *Test Breaker.*—The majority of the work has been carried out on the E.R.A. heavy-duty experimental air blast circuit breaker. This consists essentially of an interrupter head or arc chamber, to which air is admitted from a storage reservoir through a control valve. The arc chamber is fitted

* Based on Report Ref. G/T296 of the British Electrical and Allied Industries Research Association.

† Only the axial-flow type of circuit breaker has been considered in this report.

‡ The abbreviation R.R.R.V. will be used for "Rate of Rise of Restriking Voltage."

with three electrodes : the nozzle electrode, through which air exhausts to atmosphere, and the lower and probe electrodes, situated upstream and downstream of the nozzle respectively. Arcing takes place between the lower and probe electrodes, the arc being surrounded by the jet of air flowing through the nozzle, and being thus exposed to the cooling and scavenging action of this high-velocity air stream.

Preliminary work revealed the presence of a pressure oscillation in the arc chamber, initiated by the transient changes taking place at the beginning of the arc period. This oscillation, having a frequency of the same order as that of the changes being considered, made the interpretation of the records difficult.

In order to change the frequency of the oscillation, the length of the arc chamber was reduced to the smallest possible value by removing the large interrupter head from the breaker, and replacing it by an electrode housing of much smaller dimensions. The smaller volume thus obtained for the arc chamber not only led to an increase in the frequency of oscillation, but also led to greater rates of change of pressure, thus facilitating the measurement of this quantity.

A section through the arc chamber, whose volume is 0·38 cubic foot, is given in Fig. 3, whilst Fig. 2 shows the electrode arrangement and the recording points for nozzle static pressure. For the purpose of the tests, a solenoid-operated pressure-retaining valve (see Fig. 2) was fitted on the downstream side of the nozzle in order to keep the nozzle substantially closed until just before the arc period. This valve could be tripped open

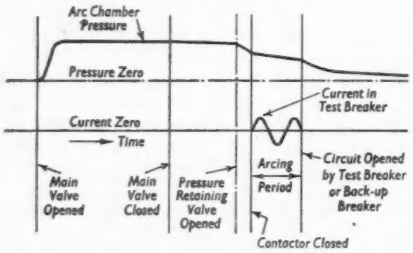


Fig. 4—Sequence of events during a test

approximately 15 milliseconds (accurately controlled) before the S.S.C.§ leaving the nozzle quite clear and unobstructed. The pressure-retaining valve was fitted to provide more easily controllable timing of the S.S.C. in relation to the arc chamber pressure. Its use also enabled tests to be carried out at given reservoir pressures, using higher arc chamber pressures than would otherwise have been possible—an advantage, particularly when using the larger nozzle sizes.

The supply of current to the circuit breaker under test was established by the closing of a contactor or making switch, the mechanism of which was designed to give " contact closure " at an instant accurately determined in relation to the tripping impulse supplied to it.

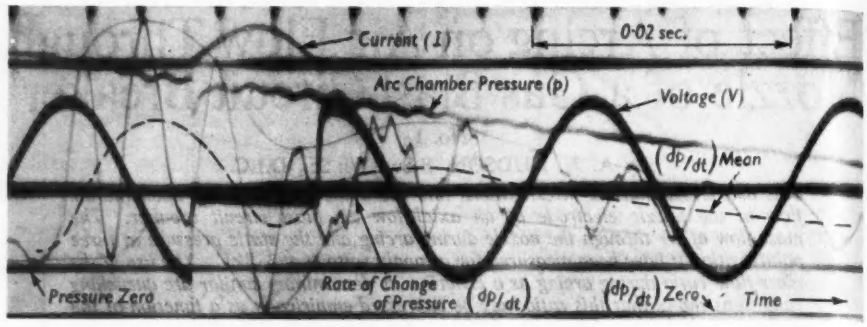
The use of a " point-on-wave " selector‖ in conjunction with a trip unit¶ enabled the required tripping impulse to be supplied to the contactor, and contact closure (or S.S.C.) to be achieved, at any desired instant (within ±0·1 millisecond) in relation to the voltage across the test breaker.

Arcing between the lower and probe electrodes was initiated by means of a fine copper

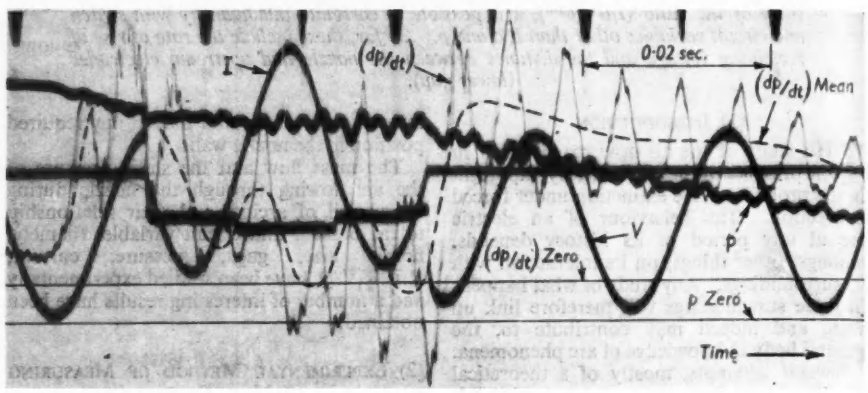
§ The abbreviation S.S.C. will be used for " Start of Short Circuit."

‖ An electronic device giving an impulse of 100V peak at any desired instant (within ±0·01 millisecond) in relation to a voltage wave.

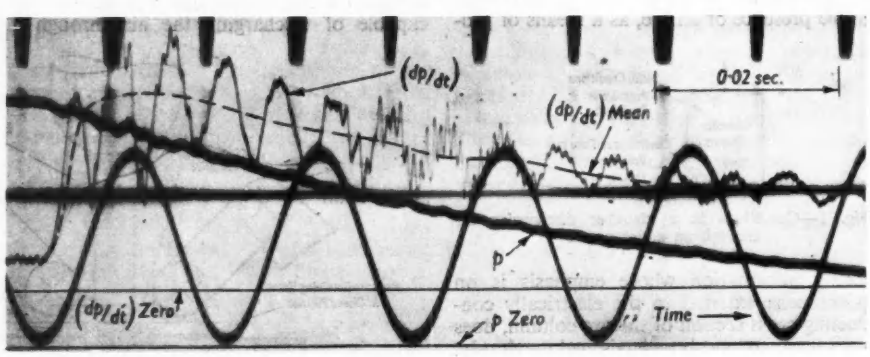
¶ A unit initiated by the point-on-wave selector, giving a 1000V impulse for energising the tripping solenoid of the contactor.



(*a*) Clearance in 1 half-cycle by test breaker



b) Failure to clear by test breaker



(*c*) Test with no arc present. Nozzle diameter and pressure as in (*b*)

Fig. 5—Typical examples of $^{dp}/_{dt}$ records obtained in the tests

fuse wire connected between them. Records indicated that the fusing of the wire is completed within 0·3 millisecond of the S.S.C.

The sequence of events for the tests is given in Fig. 4. It will be observed that the arcing period is delayed until after the main air control valve has closed so that no air flows into the arc chamber during arcing. The short-circuit current continues to flow after the closing of the contactor until the test breaker extinguishes the arc formed between its contacts, or, if it is incapable of doing this, until a " back-up breaker "** clears the circuit.

(3.2) *Quantities Recorded During the Tests.*—Recordings were made during each test, using Duddell oscillographs, of the following quantities :—

(i) Rate of change of arc chamber pressure (dp/dt).
(ii) Arc chamber pressure.
(iii) Nozzle static pressure.
(iv) Electrical quantities.

(3.2.1) Rate of Change of Arc Chamber Pressure (dp/dt).—In the early work on this subject the rate of change of arc chamber pressure was determined by measuring the slope of the pressure-time curve. The values of dp/dt obtained in this way, however, were subject to considerable error, owing to the small pressure differences involved, and for this reason a direct recording of dp/dt was deemed preferable.

Two methods have been used for this purpose, the first employing a diaphragm pressure pick-up having the diaphragm connected to the anode of a movable anode transducer valve, whose anode current then gives a measure of the pressure. The output of the transducer valve is supplied to a simple capacitance-resistance differentiating circuit, the value of the dp/dt thus resulting being recorded, after amplification, by a Duddell oscillograph.

In the second method a constant voltage is applied across a capacitance type pressure pick-up in series with a high resistance, producing a current proportional to the rate of change of capacitance, and therefore proportional to dp/dt. The voltage across the resistance element thus gives a measure of dp/dt and is recorded as before. The latter method, although giving an improved differ-

** A second breaker in series with the test breaker and capable of clearing the circuit with ease under the worst conditions to be used in the tests.

entiation, is rather more subject to electrical interference from the associated circuit.

Typical examples of the records obtained are given in Fig. 5, one for the case of a clearance in one half cycle, one for a failure, and one for a test with no current.

An undesirable feature of the dp/dt record is the presence of an oscillation of considerable amplitude, due to the relatively low amplitude pressure oscillation referred to in paragraph (3.1). The record as obtained gives the dp/dt at the particular point in the chamber at which the recorder is attached whereas for the purpose of determining mass flow values it is the rate of change taking place in the arc chamber as a whole which is required. This "space mean" rate of change, however, is substantially represented by the mean of the dp/dt record actually obtained, which can be determined from the record after drawing the envelope containing the oscillation referred to above, as indicated in Fig. 5.

The value of dp/dt in the arc chamber was recorded at the point indicated in Fig. 3.

(3.2.2) Arc Chamber Pressure.—The arc chamber pressure was recorded at the same point as in the case of dp/dt. The measurements were made using a transient pressure recorder employing either a capacitance pick-up or a movable anode transducer valve pick-up.

(3.2.3) Nozzle Static Pressure.—The static pressure was recorded at holes in the nozzle wall (see Fig. 2). In order to reduce attenuation and lag in the recording system, the tubes connecting the nozzle to the capacitance pressure heads were reduced to the minimum possible length.

This method of measurement will only give reliable values of nozzle static pressure when the air stream maintains contact with the nozzle wall throughout, i.e. when no "breakaway" of the stream from the wall occurs.

(3.2.4) Electrical Quantities.—The remaining quantities recorded were the open circuit voltage, the arc voltage across the breaker electrodes, and the short circuit current.

(4) Test Data

The tests may be divided into four sets comprising a total of about 600 in all. For all except Set 4, tests were carried out at a supply voltage of 3·8kV r.m.s. and at symmetrical currents, I, between 1000A and 8500A r.m.s. for each of four nozzle diameters, d (namely 1·0cm, 1·5cm, 2·0cm and 2·5cm), and for each of three values of lower gap, l_v (namely 0cm, 1·0cm and 2·0cm).

Sets 1 and 2, which were in the nature of exploratory tests, were carried out at nominally fixed values of arc chamber pressure, p, at S.S.C., namely at 80 lb and 115 lb per square inch gauge. The values of dp/dt for these tests were obtained by measuring the slope of the pressure-time curves. The results of the tests indicated the existence of a law expressing mass flow as a function of $I/d^{1\cdot5}$ (see paragraph 5.1.2).

On the assumption that this law remained valid over an extended pressure range, tests were carried out in Set 3 at three values of $I/d^{1\cdot5}$, namely, at 1000, 2000 and 3000, respectively, covering a range of arc chamber pressures from 20 lb to 140 lb per square inch gauge at S.S.C., the above ranges of current nozzle diameter and lower gap, and using a circuit having an approximately constant value of rate of rise of restriking voltage†† equal to 725V per microsecond.

A further series of tests, Set 4, at three other values of R.R.R.V. (namely, at 170V, 290V and 1170V per microsecond) were carried out at a fixed symmetrical current of 3950A r.m.s., at a fixed lower gap of 1·0cm, but using the four nozzle diameters 1·0cm, 1·5cm, 2·0cm and 2·5cm, and covering the full range of arc chamber pressure at S.S.C. from 20 lb to 140 lb per square inch gauge.

Static pressures were measured at three positions in the nozzles (see Fig. 2), namely, at *B*—on the entry radius at the upstream end, at *C*—approximately at the *vena contracta*, and at *D*—at the downstream end of the nozzle.

The electrode arrangement is given in Fig. 2. In order to prevent undue erosion of the electrodes under the influence of the arc, the nozzle material used in all four sets of tests was elkonite,‡‡ the probe electrodes were of $\frac{1}{8}$in diameter tungsten, whilst the lower electrodes were of $\frac{1}{16}$in diameter tungsten for most tests, but of elkonite for the remainder.

For each of the four nozzles, the entry radius was of such a magnitude as to ensure no breakaway of the air stream from the nozzle, thus ensuring reliable static pressure measurements and facilitating a comparison of these pressures for the different nozzles.

(5) Experimental Results

(5.1) *Mass Flow.*—(5.1.1) Method of Representing Mass Flow.—For this work, the minimum mass flow during the first half-cycle of arcing has been considered as the quantity most representative of the effect of the presence of the arc upon the mass flow. Mass flow values have been determined from the Duddell records and expressed in a non-dimensional form by a ratio defined as follows :—

Minimum Mass Flow Ratio§§ during first half-cycle :—

$$(m)_{min}=\frac{\text{Minimum mass flow during first half-cycle}}{\text{Mass flow at same pressure level with no arcing.}}$$

$$=\frac{(dM/dt)\text{ with arcing}}{(dM/dt)\text{ with no arcing}}\Big\}\text{At arc chamber pressure } p \text{ (abs.)}$$

$$=\frac{(dp/dt)\text{ with arcing}}{(dp/dt)\text{ with no arcing}}\cdots\cdots\text{From appendix equation (4)}$$

(5.1.2) Relationship between Mass Flow and the Current and Nozzle Size.—A plot of the mass flow ratio against current for a fixed nozzle diameter and pressure, and against nozzle diameter for fixed current and pressure, gives two sets of curves, each of approximately exponential form. On this basis, it was assumed that the mass flow ratio (m) could be expressed as an exponential function of I and d, of the form :—

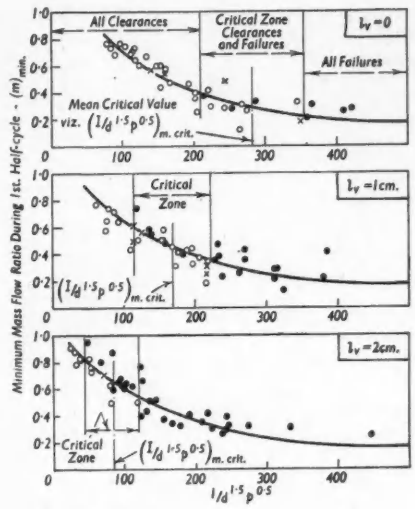
$$m=e^{k_1 I d^a}.$$

where :—

I=the r.m.s. current in the first half-cycle of arcing.
d=the nozzle diameter.
k_1 and a are constants.

The test results of Sets 1 and 2 have been found to conform to such a law, the constant (a) has a value of about 1·5 for the two values of arc chamber pressure, namely, 80 lb and 115 lb per square inch gauge, used in these tests. The tests of Set 3 were planned on the assumption that a similar relationship held over the extended range of pressure from 20 lb to 140 lb per square inch gauge. The test results confirmed this assumption.

It follows, therefore, that, for the ranges of current, nozzle diameter, pressure and lower gap covered in these tests, the mass flow at constant pressure may be expressed as a function of $I/d^{1\cdot5}$.



Minimum Mass Flow Ratio.

$(m)_{min}=\frac{\text{Minimum mass flow through nozzle during first half-cycle of arcing}}{\text{Mass flow under same conditions with no arcing}}$

O—Clearance in one half-cycle.
×—Clearance in two half-cycles.
●—Failure to clear by test breaker.

Quantity	Range covered in the tests
I—Current, amperes r.m.s.	1000–8500
d—Nozzle diameter, cm	1·0–2·5
p—Arc chamber pressure at S.S.C., lb/sq in abs....	35–155
R.R.R.V.—Rate of rise of restriking voltage, volts per micro-second...	725 (mean)
l_v—Lower vertical gap, cm (see Fig. 2)	0, 1·0 & 2·0

Fig. 6—Curves of minimum mass flow ratio in first half cycle against $I/d^{1\cdot5}p^{0\cdot5}$ for three values of lower gap (supply voltage=3·8kV r.m.s.)

(5.1.3) Extension of the $I/d^{1\cdot5}$ Law to Include the Arc Chamber Pressure.—The tests of Set 3, covering an extended range of arc chamber pressure, have been examined with a view to discovering whether any simple relationship exists between mass flow, current, nozzle diameter and pressure.

It has been found that the mass flow can be approximately represented by a function of the form $(Ip^b/d^{1\cdot5})$, the best fit being given when the index, b, equals $-0\cdot5$. It, therefore, follows that, to a first approximation, the mass flow can be represented as a function of $(I/d^{1\cdot5}p^{0\cdot5})$, as shown in Fig. 6, in which the curves are given for three values of lower vertical gap.

(5.1.4) Effect of Lower Gap on Mass Flow during Arcing.—Comparison of the three curves in Fig. 6 indicates that they are of almost identical shape, but with a slight bodily shift of the curve towards the mass flow axis for increasing values of lower gap. It therefore follows that the lower gap may be taken into account by a function of the form $(I/d^{1\cdot5}p^{0\cdot5}+k_2 l_v)$, where k_2 is a constant. Within the practical range, however, the effect of l_v is small, and may be neglected as a first approximation.

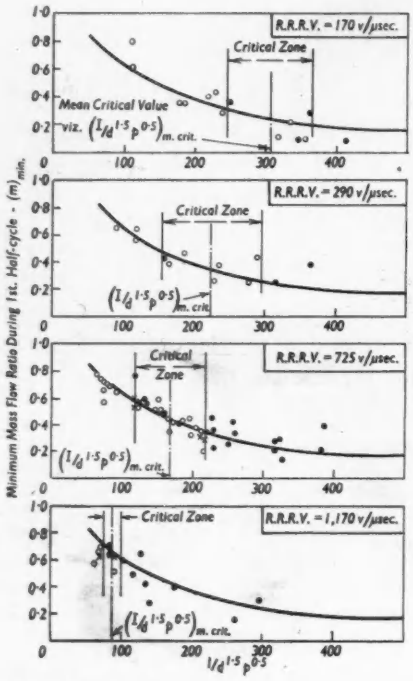
The existence of a critical zone of mass flow, above which a breaker would clear a given fault condition, and below which it would fail to clear the fault, and within which a mixture of clearances and failures occur, is demonstrated by Fig. 6 for all three values of lower gap. The number of tests carried out, however, is insufficient to determine the true boundaries of the zone.

The existence of a critical zone is the more remarkable since the curves of Fig. 6 are each based upon the results of tests using four different nozzle diameters, the critical zones for each nozzle size substantially coinciding. This fact clearly indicates that

†† Recorded by restriking voltage indicator for each circuit condition, the R.R.R.V. being obtained from the record by means of a vectorial method, now under consideration for adoption as a standard method, by the International Electro-Technical Commission.

‡‡ A sintered, tungsten-copper material possessing good arc-resisting properties.

§§ In general, throughout this report the term "mass flow" has been used to mean the minimum mass flow ratio during the first half cycle of arcing.



Minimum Mass Flow Ratio.

$(m)_{min.}$ = Minimum mass flow through nozzle during first half-cycle of arcing / Mass flow under same conditions with no arcing

O—Clearance in one half-cycle.
×—Clearance in two half-cycles.
●—Failure to clear by test breaker.

Quantity	Range covered by the tests
I—Current, amperes r.m.s.	1000–8500
d—Nozzle diameter, cm	1·0–2·5
p—Arc chamber pressure at S.S.C., lb/sq in abs.	35–155
R.R.R.V.—Rate of rise of restriking voltage volts/micro-second	170–1170
l_v—Lower vertical gap, cm (see Fig. 2)	1·0 throughout

Fig. 7—Curves of minimum mass flow ratio in first half cycle against $I/d^{1\cdot5}p^{0\cdot5}$ for four values of R.R.R.V. (supply voltage=3·8kV r.m.s.)

the extinguishing power of a breaker is closely related to the mass flow of air through the breaker nozzle during arcing.

The mid-point of the critical zone will be taken as representative of the critical conditions as far as mass flow, current, nozzle diameter, and arc chamber pressure are concerned. Thus, the quantity $(I/d^{1\cdot5}p^{0\cdot5})_{m.\,crit.}$ will be taken to represent the mean critical value of $(I/d^{1\cdot5}p^{0\cdot5})$. The relationship between $(I/d^{1\cdot5}p^{0\cdot5})_{m.\,crit.}$ and the lower gap is given in Fig. 8.

(5.1.5) Effect of R.R.R.V. upon the Mass Flow during Arcing.—The results of the

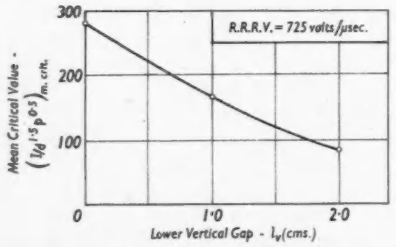


Fig. 8—Curve of mean critical value $(I/d^{1\cdot5}p^{0\cdot5})_{m.\,crit.}$ against lower gap (supply voltage=3·8kV R.M.S.)

tests of Set 4, at varying values of R.R.R.V., were plotted as before in the form : minimum mass flow in the first half-cycle of arcing against $(I/d^{1\cdot5}p^{0\cdot5})$, for the case of a 1cm lower vertical gap (see Fig. 7). Variation of R.R.R.V., as expected, has little, if any, effect upon the shape of the mass flow curves. The critical zone, however, although not so precisely fixed as in the lower gap tests, on account of the fewer tests that were made, changes its position with R.R.R.V. as indicated in Fig. 7. The mean critical condition $(I/d^{1\cdot5}p^{0\cdot5})_{m.\,crit.}$ has been plotted against R.R.R.V. in Fig. 9.

(5.1.6) Application of the $(I/d^{1\cdot5}p^{0\cdot5})$ Law at Higher Powers.—The question of interest which arises from the foregoing results is

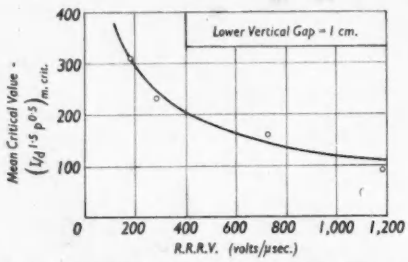


Fig. 9—Curve of mean critical value $(I/d^{1\cdot5}p^{0\cdot5})_{m.\,crit.}$ against R.R.R.V. (supply voltage=3·8kV R.M.S.)

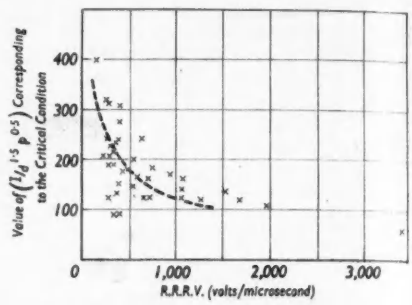
whether or not the curves of $(I/d^{1\cdot5}p^{0\cdot5})_{m.\,crit.}$ against lower gap and R.R.R.V. can be applied to conditions outside the ranges of voltage, current, nozzle size and arc chamber pressure covered in these tests. Although no test results were available in which the mass flow during the arc period had been measured it was considered that some idea of the validity of such an extrapolation could be gained by considering the results of higher power tests in which the critical clearing pressures|||| had been determined.

A preliminary check has been made with a limited set of data of this type, obtained from tests on the E.R.A. experimental air blast breaker and carried out under the following conditions :—

The values of the quantity $(I/d^{1\cdot5}p^{0\cdot5})$ corresponding to some condition within the critical zone (formerly considered the critical clearing condition) have been plotted against R.R.R.V. for these tests (see Fig. 10). The

System voltage	6·6kV to 11·0kV r.m.s.
Current (I)	11,000A to 22,000A r.m.s. (one at 32,000A)
Nozzle diameter (d) ...	1¼in, 1⅝in and 2½in, i.e. 3·2cm, 4·5cm, 6·4cm respectively
Arc chamber pressure at S.S.C.(p)	50 lb to 450 lb per square inch absolute

dotted curve, a reproduction of Fig. 9, is based upon the smaller scale tests, which



– – – – –Curve from tests described in this report.
× × × × Results from tests at higher powers (see para. 5.1.6) plotted in the same manner.

Fig. 10—Application of mass flow relationship to conditions outside the ranges of voltage, current, nozzle size and pressure covered in these tests

form the subject of this report, covering the ranges given in paragraph (4).

It will be seen that, in spite of the wide differences in current, nozzle diameter and pressure, between the low and high-power tests, those at the higher powers conform very well to the values derived from the lower power test. Further work is necessary, however, to establish this with certainty.

(To be continued)

Joint Metallurgical Societies' Meeting in Europe

No. III—MEETINGS IN FRANCE

(*Concluded from page* 219, *August* 12*th*)

During June, the Iron and Steel Institute and the Institute of Metals organised a Joint Metallurgical Societies' Meeting in Europe which was attended by representatives from this country, Belgium, France, Germany and Sweden, and attracted across the Atlantic a large number of Canadians and Americans. Our American Editor attended the meeting and we arranged that he should report upon that part of its proceedings which took place on the Continent, in the belief that it would interest readers here—and on the Continent—to learn what, in particular, would attract the attention of one familiar with American practice.

St. Germain-en-Laye

THE morning of the final day of the meeting was spent by the delegates visiting the Institut de Recherches de la Siderurgie (I.R.S.I.D.) which is situated on a pleasantly wooded 17-acre site at St. Germain-en-Laye, north-west of Paris. This central research establishment of the French iron and steel industry may be considered to be the opposite of B.I.S.R.A. in the U.K. and the Max-Planck-Institut in Germany —yet there is a fundamental difference in the scope of work undertaken by these establishments. While the British and German organisations cover the entire field of iron and steel making and fabrication, it is perhaps surprising that I.R.S.I.D. so far has limited its work to the fields of raw materials and primary iron and steel making, while practically ignoring the mechanical working aspects, such as rolling, forging, extrusion and wire drawing. Compared with the magnificent mechanical working plant installed at the Sheffield laboratories of B.I.S.R.A. and the not so up-to-date but nevertheless adequate equipment at Düsseldorf, the total absence of experimental rolling mill and related plant at St. Germain-en-Laye seems hard to understand. It would appear that the French industry at present prefers its research institute to concentrate its efforts on the primary aspects of iron and steel making, but there are indications that at a future date, additional plant will be installed to facilitate research in the secondary fields of metal fabrication.

I.R.S.I.D. was founded in 1944, under the joint control of the Chambre Syndicale de la Siderurgie Française and of the French Government. In accordance with its official aims, the main function of the Institute is technical and scientific research applied to those metallurgical problems which are more likely to be solved by collective than individual endeavour. It is now particularly devoted to the improvement of production

||| I.e. the pressure formerly accepted as a limiting condition above which a breaker clears and below which it fails to clear a given fault condition. It is now known that this limiting condition is represented by a range of pressure, rather than by a particular value of pressure.

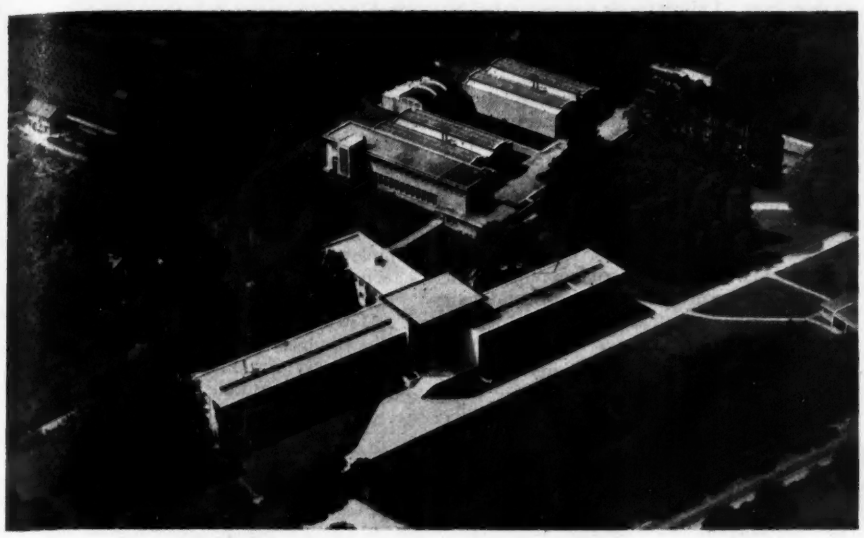


Fig. 12—Aerial view of laboratories at St. Germain-en-Laye

processes with a view to cutting down costs or improving quality, and to the study of the raw materials—mainly ores and coke—required by the iron and steel industry. In 1947, I.R.S.I.D. began the construction of the large laboratories it required at St. Germain-en-Laye. Their construction was completed toward the end of 1952, and the laboratories have been in full use since 1953. Our accompanying illustrations show, respectively, an aerial view of the entire laboratories, and views of the mechanical testing department, the creep testing department and the high frequency furnace section of the steel melting shop. The work of the Institute is financed by means of levies on iron and steel sales. For ordinary irons and steels delivered in France and in the Saar, the tax is compulsory and amounts to about 0·3 per cent of the value of the products. Exported products and high quality and special steels carry a voluntary contribution at generally the same rate.

In addition to its main laboratory facilities at St. Germain-en-Laye, a pilot plant is operated by I.R.S.I.D. for the study of minerals at Saulnes near the Belgian border, and several research projects are being sponsored at university laboratories and at some of the important steel works. The Institute also collaborates with other organisations, both in France and in other countries, in joint researches of general interest. Examples of these are studies on the Lorraine coking coals, on ingot moulds, heat resistant steels, railway rails and tyres, enamelling sheet, weldability of steel and corrosion. I.R.S.I.D. also participates in the investigations which are currently being conducted on an international scale on flame radiation and on the low-shaft furnace. Supplementing these principal research activities and projects, I.R.S.I.D. was requested by the French Iron and Steel Federation in 1950 to establish at Metz a centre for advanced studies in ferrous metallurgy, designed to round out the education of graduate engineers who have already spent two or three years in industry. Finally, it maintains direct connections with the Centre de Documentation Siderurgique and contributes to its financing.

The Administrative Council, a group composed of eleven members who are appointed for two years by the French Iron and Steel Federation, defines the general policies of I.R.S.I.D. and controls its financial management. Meetings are held about every two months, and are attended by a representative of the Ministry of Commerce and Industry as well as by a direct representative of the Federation. The Scientific and Technical Committee decides upon research programmes within the general framework of directives provided by the Administrative Council. The thirteen members include company executives, production heads, directors of industrial laboratories, and a representative of the National Centre for Scientific Research. They meet four times a year. The Scientific Commission is in charge of deciding upon the actual research programmes at the Institute and serves as liaison with universities and plant laboratories. This commission consists of six university professors, experienced in specific fields related to metallurgy and six metallurgical scientists. It meets regularly two or three times a year.

The Institute's activities are organised in various divisions and departments. Some of these research projects are housed at the headquarters at St. Germain-en-Laye, others at various outside organisations. The latter include the mineral division, the coke and pig iron division, the steel making division and the rolling mill division. The headquarters of the mineral division are at a small mineralogy laboratory in Paris ; the work consists largely in making a descriptive inventory of the mineral resources of France and studying processes for ore beneficiation and reduction in a pilot plant at Saulnes. The coke and pig iron division is installed close to several large steel manufacturing plants at Longwy. Its purpose is to study the blast furnace, particularly with a view to utilising lower-grade coke and ores. The steel making division has its headquarters at the Saint-Germain laboratories, but most of the personnel work in the research departments of the large manufacturers. While their province is the study of all aspects of steel making, emphasis is placed primarily on Thomas steel ; specific projects include the pre-refining of pig iron, the use of oxygen for blowing, and the effervescence in the ingot mould. While the rolling mill division has not yet been completely organised, certain problems are being studied in collaboration with the School of Mines at Saint-Etienne, and future work is expected to lie in the fields of hot workability, elongation and spread during rolling, and calculation of stresses in rolling mill stands.

The main laboratories at Saint-Germain, which were visited by the delegates, are organised in three departments and one division : the metallographic department, the physics department, the analytical chemistry department, and the high-temperature physical chemistry division. The metallographic department is much more extensive in scope than its name would indicate. In fact, its jurisdiction includes general studies of properties of steels and irons in the solid state, including mechanical tests at both high and low temperatures, and research in the behaviour of ferrous products in service. Some of the studies in progress at the present time deal with heterogeneity of steel, internal friction, fatigue tests, heat resistance of steels, service failures of railway rails and tyres, low-temperature behaviour of welded steel structures, and preparation of an atlas of "T–T–T" curves for French structural steels. The physics department is currently limited to researches utilising X-rays. Two present projects deal with plastic deformation of metals and structural transformations in steel. The chemical analysis department makes special analyses requested by the other divisions of the laboratories, conducts corrosion tests and handles general chemical problems. The high-temperature physical chemistry division has instituted some fundamental investigations of the physical chemistry of steel making, including viscosity, surface tension of liquid

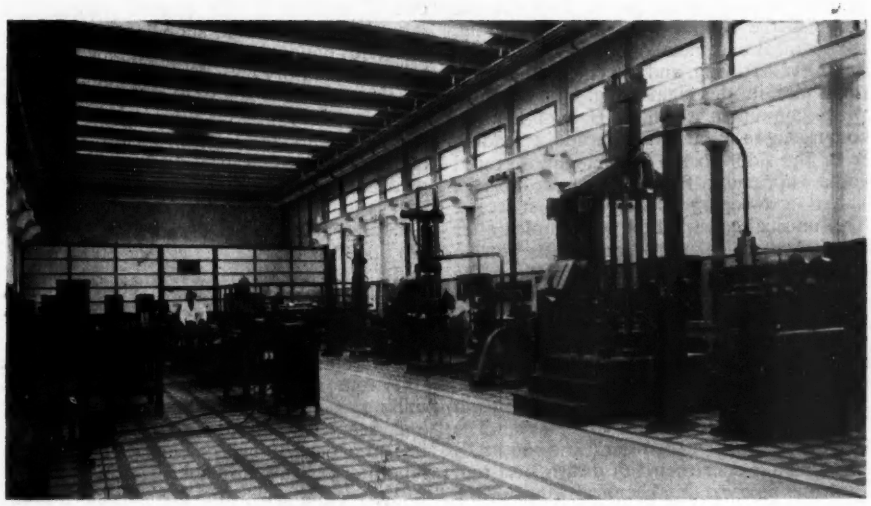


Fig. 13—Mechanical testing laboratory of the I.R.S.I.D.

metals, and thermodynamics of sulphur and silicon with particular reference to desulphurisation in the blast furnace. In addition, there are a general services division, which has jurisdiction over equipment and maintenance ; a statistical division, which makes statistical analyses of test results ; a documentation division, which manages a library of 1100 volumes and 119 periodicals, and an administrative division. A small portion of the I.R.S.I.D. funds goes to a number of young engineers who are pursuing special studies at French or foreign universities or laboratories with the idea that they will return to the laboratories of the Institute and apply whatever new techniques have been learned. In the United States, for example, I.R.S.I.D. now has such representatives at the Massachusetts Institute of Technology, the Institute for the Study of Metals at the University of Chicago, the Carnegie Institute of Technology and Lehigh University.

From an architectural point of view, the laboratories at St. Germain constitute a truly modern, functional design resulting in a pleasant, well-balanced group of buildings blending perfectly with the wooded site. As indicated in our aerial view, the main administrative building has been laid out in the form of an asymmetric T, 360ft wide and 125ft deep along the central wing, which will allow expansion of any portion of the structure without destroying the present balance of design. Administration occupies the central wing of the building, the physical and metallographic laboratories are in the left wing, and the chemical laboratories are in the right wing. These three wings conjoin in a central Hall of Honour comprising a clear glass facade extending from the floor to the overhanging terraced roof. Springing from the centre of the hall is a sweeping all-steel spiral staircase. This unusual construction was adopted after exhaustive calculations and tests on a one-fifth scale model had been made. The 30ft long spiral box beam is of trapezoidal cross section, built from 0·560in thick open-hearth mild steel plate ground to 180 grit finish, bonderised and finished with a colourless resin varnish. The inclined faces are welded from three plates, and the top and bottom faces welded from two plates. The steps are rubber-treaded steel, and the trellis balustrade is constructed of drawn steel rod. Both the physical and chemical wings of the building are three stories high with interleaved mezzanine floors that conceal all service lines. Laboratories are separated by either glass or opaque partitions.

Along the back of the first floor of the physics wing are store rooms, cloak rooms, dark rooms and an X-ray diffraction laboratory. Along the front are the radiographic laboratories and rooms for pyrometry, dilatometry and colorimetry. The first floor houses laboratories for X-ray and electron diffraction work, electrical and magnetic testing, and mechanical testing of microspecimens. On the top floor is the metallographic department which contains equipment for microscopy, macroscopy, heat treatment of small specimens, salt baths, and isothermal dilatometers for establishing " T-T-T " curves. Laboratories for spectrographic analysis and analysis of gases in metals are on the first floor of the chemistry wing. On the second floor are the corrosion laboratories, and the physico-chemical laboratories with equipment for measuring viscosities, surface tensions, and densities of slags as well as calorimeter bombs. Laboratories for general chemical analysis are on the top floor.

The Jean Rist Laboratory is the other principal building in the group. Connected by tunnels to the main building, it is laid out roughly in the shape of a U. The two main wings are steel framed shops, 39ft wide, 110ft long and 32ft high. The right-hand wing houses the melting and hammer shops, the left wing is the machine shop. The central section is an electric substation. Abutting the machine shop is a reinforced concrete building housing the mechanical testing laboratory on its first floor and offices on the second. Each of the shop buildings is equipped with two 3-ton cranes. Present equipment in the melting shop includes a 10kW, 200,000 c/s Philips electronic generator for 5 kg melts of steel, and two high-frequency furnaces, one for handling 300 kg melts under atmosphere, the other for melting and casting 50 kg melts under a vacuum of 0·1mm Hg. The hammer shop is equipped with an air hammer and a recirculating furnace which can heat work to a forging temperature of 2450 deg. Fah. The machine shop, which comprises some forty-four machine tools, including lathes, milling machines, drill presses, saws, grinders and heat treating furnaces, produces both test specimens and special equipment for the laboratory. The mechanical testing laboratory is equipped with five tensile testing machines, nine fatigue testing machines, three hardness testers, two torsion testing machines, a universal sheet tester, three Charpy impact testing machines, a magnetic sorter and a metalloscope. The creep testing laboratory has twenty-two creep machines on the first floor and fourteen stress-rupture machines installed in the basement. The temperature of the stress-rupture machines is recorded on one central potentiometer. These two rooms are air-conditioned, and the zone from 1½ft to 4½ft above the floor is free of air currents. To avoid draughts completely on the creep equipment a protective screen is thrown around each machine.

I.R.S.I.D. currently employs a staff of 420, 110 of whom are university graduates. As the youngest of the European co-operative research organisations, I.R.S.I.D. is perhaps not yet as well established as its sister institutes in other countries, but there can be no doubt that a promising start has been made in various endeavours, particularly in the fields of iron ores and coking coals, which mean so much to the French iron and steel industry. I.R.S.I.D. certainly enjoys the important advantage of completely up-to-date research facilities, which, together with an aggressive spirit of inquiry to be found here, should lead to some worthwhile results in the future.

It remains only to record the social highlight of the meeting : the official closing reception and dinner, which was held on Saturday evening at the Orangerie of the Palace of Versailles, by invitation of the Société Française de Métallurgie. The magnificent gardens and the huge vaulted gallery of the historical Orangerie provided an unforgettable setting for a truly festive occasion, and both dishes and wines were as choice and numerous as lectures and visits had been for the preceding three weeks !

In addition to its technical value, it was generally felt by the delegates that the meeting had been instrumental in paving the way for increased collaboration between engineers and metallurgists on an international basis. Members from the United States, particularly, expressed great satisfaction at the opportunity to establish personal contacts in Europe and had nothing but praise concerning the excellent organisation of the various parts of the meeting by the respective local metallurgical societies. Thus, an extremely successful " Joint Metallurgical Societies' Meeting " had come to an end and delegates could only hope that the future would soon bring another such opportunity of meeting old and new friends.

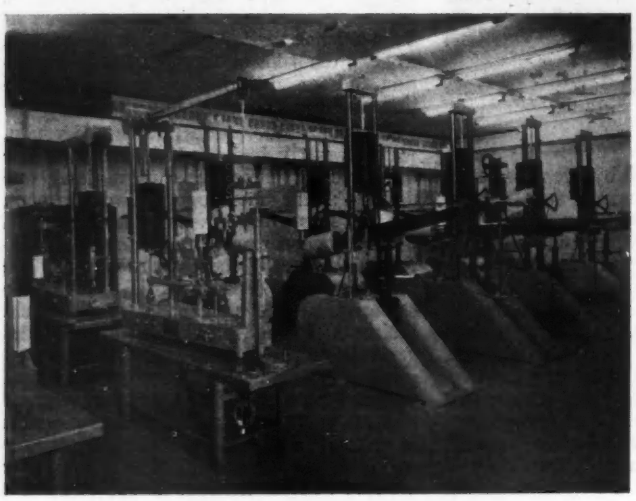


Fig. 14—Creep testing laboratory at the I.R.S.I.D.

Fig. 15—High-frequency furnace section in steel melting shop at the I.R.S.I.D.

Contribution of Nuclear Power to Electricity Generation

The role of nuclear power in the next fifty years was discussed in a group of eight papers at one of the sessions of the International Conference on the Peaceful Useful Uses of Atomic Energy, which is being held in Geneva from August 8th to 20th. An account of two of these papers is given here : the first, by Sir John Cockcroft, is reproduced in extenso; *the second, by Mr. J. M. Kay, in the form of abstracts.*

Contribution of Nuclear Power to U.K. Energy Resources up to 1975*

THE development of nuclear technology in Britain has now reached a stage when it can be applied to the large-scale production of electrical power and the United Kingdom Government has decided to embark on a ten-year initial programme of construction of nuclear power stations. The first power station is being built at Calder Hall by the Industrial Group of the Atomic Energy Authority, and Sir Christopher Hinton will describe this at a subsequent session of this conference. The power station will derive its heat from two graphite-moderated reactors and the heat will be transferred to steam generators by carbon dioxide gas under pressure. We expect this power station will deliver over 50MW of electricity to the national grid. Three more stations of this type are to be built in the near future.

The output and efficiency of the graphite-moderated nuclear power stations can be increased by increasing the pressure and temperature and improving the heat transfer characteristics. Industrial organisations are now engaged on designing such improved power stations with technological help from the Atomic Energy Authority. The Central Electricity Authority expect to build twelve of these power stations for successive completion between 1960 and 1965. The output of an individual power station is expected to rise from 100MW to at least 200MW in successive designs. The total installed capacity should therefore exceed 2000MW by 1965 by which time nuclear energy will be doing the work of several million tons of coal a year.

After 1965, when industry has gained experience of construction and the Electricity Authority of operation of these stations, the programme is expected to expand much more rapidly until by 1970 most of the new British power stations should be of the nuclear type. By 1975 the installed capacity is likely to rise to between 10,000MW and 15,000MW. The nuclear power stations will probably be operated as base load stations and so will supply a higher proportion of the power in relation to their capacity than coal stations. So by 1975 nuclear power should be doing the work of about 40,000,000 tons of coal a year—providing about 40 per cent of the energy for electricity.

Looking further ahead, a rough estimate of United Kingdom electrical power requirements for the year 2000 can be obtained by projecting forward the curves of demand given in Robinson's and Daniel's[1] paper to this conference. The energy requirement for electricity production is then forecast as about 250 million tons of coal equivalent. Probably the whole of the additional energy over 1975 requirements will have to come from nuclear sources. So that we can expect nuclear power to be doing the work of 150 to 200 million tons of coal by the year 2000 in Britain.

We can compare this with world requirements by referring to the Robinson and Daniel paper to the conference. They forecast the requirements for electricity in the year 2000 to be 9000 milliard units (9×10^{12}), which would require the use of 3½ milliard tons of coal equivalent a year if it were produced solely in thermal power stations. They estimate that the total demand for primary fuel will be not less than 7½ milliard tons of coal equivalent a year, and after comparing these figures with the available reserves of the conventional fuels, including hydro-electricity, they ask whether it will be practicable for the greater part of the electricity demand—say, 2 or 3 milliard tons of coal equivalent a year—to be met by nuclear energy.

The requirements of nuclear fuel for this task depend on the efficiency of utilisation of the fission energy of uranium. If a 33 per cent utilisation could be obtained, 1 ton would do the work of 1,000,000 tons of coal. We expect to approach this high efficiency by successive steps in the development of nuclear power stations.

The graphite-moderated reactors with which Britain proposes to start her nuclear power development have the great advantage of being able to use natural uranium fuel—they do not need supplies of enriched uranium from a diffusion plant. With these reactors we expect in a single fuel cycle to extract the heat equivalent of at least 3000MW days per ton of uranium giving us the heat equivalent of 10,000 tons of coal of normal British quality. This heat extraction limit is expected to be determined by the deterioration of fuel elements rather than by nuclear factors.

At the end of the first cycle the fuel elements contain a substantial amount of plutonium, together with fission products. The fission products will be extracted chemically and the uranium and plutonium can then be recycled. Alternatively, the plutonium can be used as a feed to other types of thermal reactors—such as water-moderated or sodium-graphite reactors requiring enriched fuel, or fast breeder power reactors.

A subsequent paper in this conference on fuel cycles to be presented by Dr. Dunworth[2] will show that it should be possible to recycle uranium plus plutonium fuel several times until the concentration of U235 has been reduced to a low figure and an appreciable amount of U238 has been fissioned. In this way it may be possible to increase the heat extraction per ton of uranium from 10,000 tons of coal to as much as 100,000 tons.

During this period and even earlier the type of reactor used in Britain is likely to change to a reactor giving a higher rating and output. Water moderated reactors now under study in U.K. show considerable promise as possible successors to graphite-moderated reactors. Power outputs are likely to rise to at least 150MW per reactor and capital costs are likely to fall to below £90 per installed kilowatt.

Still further improvement in uranium utilisation may be expected when fast breeder power reactors come into full scale operation. A paper to be presented to this conference by Shepherd[3] on the results obtained with the Harwell zero energy fast reactor—" Zephyr "—will show that plutonium fast reactors should have a very high gain factor. The secondary plutonium fuel bred in the reactor from U238 should be substantially greater than the plutonium fissioned in the core. We ought therefore to be able to make use of the greater part of the fissionable energy of U238 as well as U235, and to extract from 1 ton of uranium the heat equivalent of at least the million tons of coal which I have mentioned earlier. Fast breeder reactors have thus an important long-term interest in a nuclear power programme, and Kendall and Fry[4] will describe in a later session the engineering problems of the large-scale experimental fast breeder reactor we are building in Britain.

The nuclear power programme has therefore the important characteristic of promising improvements in uranium utilisation of two factors of ten as the development programme proceeds. These technological improvements are likely to be achieved more rapidly than the expansion of demands for nuclear power.

We can therefore envisage the United Kingdom nuclear power requirements for 1975 being met by an annual consumption of not more than 400 tons of uranium together with initial requirements for new power stations which might exceed 400 tons per annum.

The possible U.K. requirements in the year 2000 for the equivalent of 250 million tons of coal a year would be met by burning 250 tons of uranium or thorium a year if breeding is by then fully developed. At the same period the emerging shortage of world supplies of the conventional fuels referred to by Robinson and Daniel might be met by producing the greater part of world electricity supplies in nuclear power stations which would consume 2000 or 3000 tons of uranium or thorium a year for the purpose. There would be large additional requirements of uranium for initial investments in new reactors. The papers on uranium supplies, presented to this conference, suggest, however, that there should be little difficulty in meeting these requirements. It should be emphasised that a great many technical problems have to be solved to meet this programme. The programme is essentially flexible and may look different if it is examined ten years from to-day.

Nuclear Energy in Relation to Other Methods of Electricity Generation†

Comparison Between Nuclear and Conventional Thermal Power Stations.—It is confidently expected that within the next few years several different types of nuclear reactor will be proved in operation. In the United Kingdom the graphite-moderated gas-cooled reactor is regarded at present as the most promising design. Other types, however, such as the pressurised water-moderated reactor, the boiling water reactor, and the graphite-moderated sodium-cooled reactor are also being studied.

It is too early to say which of these alternative types will ultimately prove superior. For the purposes of the present paper, however, it will be reasonable to base our estimates on the assumption that graphite-moderated gas-cooled reactors are used in the first stage and that these will be

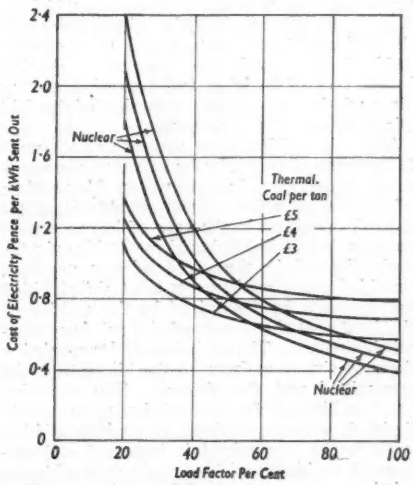


Fig. 1—Comparison between nuclear and conventional thermal power

followed in the second stage of nuclear power either by improved designs of the same basic type or by one or other of the above-mentioned types of liquid-cooled thermal reactor designed to use by-product plutonium in conjunction with either natural or depleted uranium as the fuel. The idea of a two-stage programme of this sort is of fundamental importance for the large-scale development of nuclear power.

Looking further ahead, we may assume that other types of nuclear reactor will ultimately be developed which will achieve breeding of fissile material. The plutonium-fuelled fast reactor

* "The Contribution of Nuclear Power to United Kingdom and World Energy Resources up to 1975," by Sir John Cockcroft, K.C.B., C.B.E., F.R.S.

† "The Role of Nuclear Energy in Relation to other Methods of Electricity Generation," by J. M. Kay (Messrs. Kennedy and Donkin).

and the aqueous homogeneous thorium reactor are two of the possible runners in this field.

Some indication of capital costs for nuclear plant has been given in the U.K. Government White Paper Cmd. 9389. The cost per kilowatt installed will depend on the type of reactor and on the size of unit. For purposes of comparison with conventional thermal generating stations, however, three typical figures have been taken for capital costs of nuclear plant covering the probable range during the next few years. The three lines shown for nuclear stations on Figs. 1 and 2 correspond with these different capital costs. While the earlier stations may start at the top of the range, the cost of nuclear plant is expected to fall progressively with improvements in design.

It is commonly supposed that fuel costs will be negligible for nuclear stations. This will not in fact be the case, however, unless :

(*a*) A very high level of irradiation is achieved with the fuel elements, and

(*b*) The by-product plutonium is separated out for use as a fuel in other reactors and that credit is duly allowed for this.

Making reasonable allowance for the capital charges, and for the fuel and operating costs including credit for by-product plutonium, it is possible to plot the net estimated cost of power generation from nuclear energy by means of the curves in Figs. 1 and 2. Fig. 1 shows the cost per kilowatt-hour sent out. Fig. 2 gives the annual cost per kilowatt of maximum demand. In each case the cost is plotted against the annual load factor. Also plotted on these two figures are the corresponding costs of generation from a conventional thermal station using coal at £3, £4 and £5 per ton. It must be emphasised, however, that the comparison shown on Figs. 1 and 2 is qualitative rather than quantitative. A precise estimate for the cost of power generation can only be given when the size of station, local conditions and the arrangements for fuel supply and handling are specified.

It will be observed that, under the conditions assumed for the first phase of nuclear energy and with coal at a cost of approximately £4 per ton, nuclear power should be competitive almost immediately at annual load factors of about 60 per cent and upwards. The inference is that the first commerical application of nuclear power will be for base load generation in countries which do not possess adequate supplies of cheap conventional fuels. These first stations must operate at high load factor, but the progressive reduction in the cost of building and operating nuclear plant will lead to a steady extension of the field of application of nuclear power.

The siting of base-load nuclear stations must be determined primarily by safety requirements and by the supply of cooling water. No problem of disposal of active effluent should arise under normal operation in the case of heterogeneous reactors, but facilities should preferably exist for such disposal in the event of any accident. Provided these requirements are satisfied, siting will normally be determined by the position of the load and the extent of the existing transmission system. The capital cost of transmission depends almost entirely on the kilowatts to be transmitted and the distance. The operating cost per kilowatt for transmission up to certain limits, however, goes down as the bulk of kilowatts to be transmitted is increased. Consequently, at high load factors the cost of transmission as a percentage of the total cost of kilowatts and kilowatt-hours will be reduced. In other words, while the low load factor supplies should be generated as close as possible to the load, with high load factor supplies the distance is of less importance.

Comparison Between Nuclear and Hydro-Power Stations.—Comparison between nuclear power and hydro-power is much more difficult because of the wide variation in characteristics between different hydro-electric schemes in different parts of the world. It is particularly difficult to compare capital costs because these depend greatly on the topography and on the load factor at which the hydro station is designed to operate. For instance, a station having a given total annual output, but designed to operate at very high load factor, would involve greater expenditure on the civil engineering works required to provide the additional storage compared with a station of the same total annual output to operate at lower and less rigid load factor. In plotting annual cost per kilowatt installed against load factor, therefore, it is necessary with hydro-power to take into account a varying installed capacity for the turbines and generators while working in terms of a fixed annual run-off and energy output.

At the risk of over-simplification, the costs of three representative types of hydro scheme are indicated on Fig. 2. Curve *A* refers to a large,

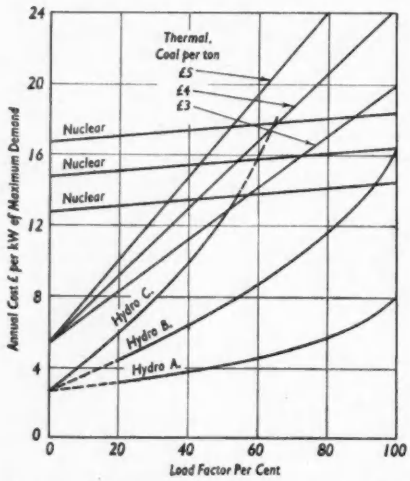


Fig. 2—Comparison between nuclear, conventional thermal and hydro power

low-head, run-of-river scheme such as one might find in Canada or on the Continent of Europe. The flatness of the curve will depend on the uniformity of flow over the different seasons of the year. In the case of glacier-fed rivers there may be a large seasonal variation in the flow and this may set a limit to the load factor at which the station can operate. In such cases, where the available power would otherwise be seriously reduced in winter, operation at higher overall annual load factor can be achieved by the addition of seasonal pumped storage.

Large low-head hydro schemes, as represented by curve *A*, can provide the cheapest power of any available in the world and nuclear energy cannot hope to compete in this territory. Countries which are fortunate enough to have favourable geographical features with large-scale resources of water power should develop these resources to the utmost without any fear of serious competition from nuclear energy within the foreseeable future.

Curve *B* refers to a large-scale hydro scheme constructed with storage in favourable terrain. This curve is steeper than curve *A* because operation at high load factor requires increased storage with correspondingly higher outlay on the civil engineering works. Power generation from such a source, however, is still competitive at all load factors with generation from thermal stations.

Curve *C* refers to medium-head hydro schemes of smaller individual size constructed in less favourable terrain. Considerable capital expenditure is necessary on the civil engineering side in connection with storage arrangements, tunnels, &c. Schemes of this kind are to be found, for instance, in Scotland. If they were designed for operation at high load factor the capital cost per kilowatt installed might be prohibitive. By increasing the installed capacity, however, and designing the stations largely for peak load operation, it is possible to generate power over the lower range of load factor at costs which are appreciably lower than the corresponding costs of generation from thermal stations. The obvious application for hydro-power of this type is to provide peak load power while working in conjunction with base load thermal stations. The advent of nuclear power will make this type of hydro station still more attractive because of the relatively favourable features of nuclear stations for base load operation.

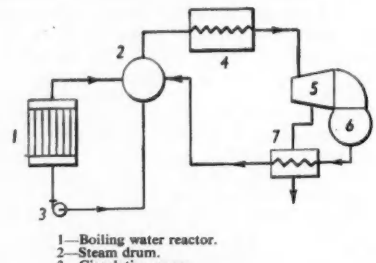
The conclusion is that nuclear energy will seldom be a competitor to hydro-power. Where hydro-power is available on a large scale with schemes of type *A* and *B* it will offer power at a lower cost than from any other available source. Only when these hydro resources have been fully developed should they be used for operation at lower load factors in conjunction with base load nuclear stations. In regions where hydro-power is available on a smaller scale, however, it should be developed from the outset in partnership with nuclear power for the purposes of meeting the peak load demand.

Methods of Meeting Peak Load Demand.—In the earlier stages, at any rate, nuclear power will tend to be used for base load operation in areas where cheap base load power cannot be obtained from other sources. Some alternative source of energy must, however, be employed for meeting the peak load demand. The use of hydro-power at low load factor has already been discussed and this application will undoubtedly increase in relative importance in the future.

At present the peak load demand for power is met largely by the older thermal stations whose fuel costs are relatively high. In course of time many existing base load thermal stations of conventional type will be down-graded to peak load operation. At a later stage it may even be necessary to design and build coal or oil-fired thermal stations especially for peak load supply, although this has not generally been justifiable in the past.

Some additional provision may have to be made, however, to assist in meeting peak load demand and to enable nuclear stations to operate economically at high load factor. Some form of energy storage would have many attractions since it would not only help in cutting off the peaks of the daily or seasonal load curve, but would also enable some of the troughs to be filled in and thus result in a greater proportion of plant being operated at high load factor. Pumped storage hydro-power is the only large scale method of energy storage that is commercially feasible to-day. Thermal storage does not at present appear to be an economic proposition. Other alternative means of energy storage, such as the Bacon fuel cell, are being examined, however, and these may have possibilities in the future.

Pumped storage hydro schemes may be expected to play a large role in partnership with nuclear power in the future pattern of energy supply. Suitable topographical conditions must be available, however. Two storage reservoirs must be provided at different levels, and the reservoir at the lower level must be of large capacity to avoid any appreciable changes of head in the tail-race or suction line. The site for a pumped storage station should preferably



1—Boiling water reactor.
2—Steam drum.
3—Circulating pump.
4—Externally fired superheater.
5—Turbine.
6—Condenser.
7—Feed-water heater.

Fig. 3—Schematic arrangement for combined nuclear and combustion heat cycle

be close to the centre of gravity of the load or within reach of grid transmission lines of high capacity. A number of different mechanical and hydraulic arrangements are possible. These include the use of separate pumps and turbines connected to the same electrical machine, designed to operate either as motor or generator, and also the use of reversible pump-turbines for low or medium head schemes. The use of two-stage pumping may be necessary, however, for high head schemes.

Another way of introducing some degree of flexibility into nuclear generating plant is to combine the use of nuclear and combustion heat in a single thermal cycle. One application of

this principle would be possible with the boiling-water type of reactor. In this scheme, illustrated diagrammatically in Fig. 3, steam would be generated directly from nuclear heat in the reactor core and would subsequently be superheated by means of a separate coal or oil-fired superheater. This arrangement would involve some additional complexity in the plant, but it would offer the advantage of combining the conservative use of nuclear heat at relatively low temperatures with the thermodynamically efficient use of combustion heat at the high temperature end of the steam cycle. Further flexibility in operation could be achieved by incorporating reheat in the steam cycle.

Transmission Problems.—Graphite-moderated, gas-cooled reactors are regarded as being inherently safe, and it should, therefore, be possible to locate nuclear power stations employing this type of reactor at convenient points on the transmission network in relation to the main centres of consumption. Availability of cooling

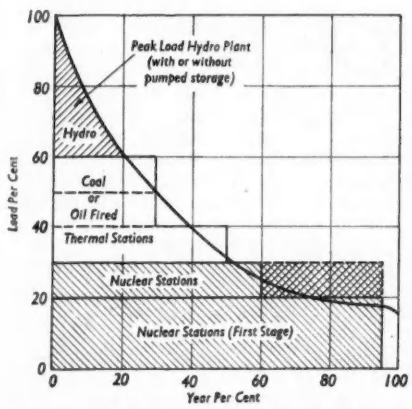


Fig. 4—Typical load duration curve showing allocation of different types of plant

water will be the principal requirement in choosing a site for a nuclear station. Densely populated areas will probably be avoided for some time to come, but no serious problem of long-distance transmission should arise.

In the later stages, however, it may become increasingly difficult to find suitable sites with adequate supplies of cooling water. Some of the more advanced nuclear reactors may also involve special siting problems such as effluent disposal in the case of certain types of homogeneous reactor. It may be necessary to locate power stations employing reactors of these more advanced types at remote sites. The problem of long-distance transmission of large blocks of power will then arise.

The situation will be similar to that encountered frequently with hydro power. Very large resources of hydro power remain to be developed in different parts of the world, but these untapped resources are generally to be found in remote areas at great distances from the main centres of consumption.

Interconnected Systems for Electric Power Generation.—The appropriate use of the various power resources, conventional thermal, hydro and nuclear, can be discussed most conveniently with the help of an annual load-duration curve. A typical example is shown on Fig. 4. Assuming that large-scale hydro power is not available in the area considered, it will be natural to employ nuclear stations for operation at very high load factor, as indicated by the lowest rectangular area on the diagram. During the first phase of development these stations will probably employ nuclear reactors of the graphite-moderated, gas-cooled type. Power generation over the middle range of load factor will be covered mainly by the existing coal or oil-fired thermal stations of conventional design. Peak load generation should preferably be met by hydro stations designed specifically for low-load factor operation. Alternatively, by using pumped storage hydro stations for peak load, it will be possible to operate a greater proportion of the total generating capacity of the system at high load factor. This would justify the construction of a correspondingly greater number of nuclear stations. This is indicated diagrammatically by the second rectangular area on Fig. 4.

It may be expected that technical advance in the design of nuclear plant will bring down the capital costs and enable satisfactory operation of future schemes to be carried on at rather lower load factors. If this development proceeds in parallel with the construction of peak load hydro and pumped storage schemes, there will be a resulting tendency for the conventional thermal power stations to be confined to a range of load factor in the middle of the load duration curve.

It is interesting to speculate on the course of events in perhaps twenty years' time, when a number of the earlier nuclear stations will be approaching the end of their economic life. With conventional thermal stations a steady lowering of the load factor normally takes place and stations originally constructed for base-load duties at high efficiency are liable to end their careers as peak-load stations. It is difficult to see how this can happen with nuclear plant, and it is probable that there will be an increasing tendency in future for power stations to be designed for operation over a specified and relatively narrow range of load factor.

In the latter stages when large quantities of concentrated fissile material become available in the form of either by-product plutonium or uranium 233 from the earlier thermal reactors, there will be greater freedom in regard to the number of different types of reactor that can be designed and operated economically. It is possible that some of these later types of reactor, which are likely to be of much smaller size and higher specific thermal rating than the earlier ones, may be both technically and economically suitable for peak load operation. The difficulties of processing and handling concentrated nuclear fuels, and particularly plutonium, should not, however, be underestimated.

Conclusions.—If one attempts to take a long term view of world energy requirements it seems that nuclear power has been harnessed just in time. The demand for electricity continues to increase at a remarkably steady rate all over the world. In the absence of a new source of energy this increase of demand would have to be met mainly by conventional thermal stations burning coal or oil. There is already a serious shortage of coal and the cost of mining it is increasing rapidly. While oil appears to be plentiful at the moment it is a relatively expensive fuel for use in a power station, and since liquid fuels are of such importance for mobile power plants of moderate size it seems right that oil should be reserved increasingly for use where a liquid fuel is essential. Coal and oil also form the basis of two of the most important sections of the chemical industry, and in future both must be regarded as valuable chemical substances rather than as raw fuels.

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Hydro-Power Projects in South India

BY OUR INDIAN CORRESPONDENT

MOST of the big hydro-power projects are situated in the north; but the south, not so well endowed with natural water resources, has registered substantial progress in power development and utilisation and, since 1947, has added about 100MW to its existing capacity of 150MW. Among the schemes completed during the last seven years are the Moyar hydro-electric scheme, the first and second stages of the Madras thermal scheme, the Madurai power station, and the extensions to Papanasam and Pykara projects. The capital investment so far amounts to Rs. 30 crores (£22·5 million). The number of villages electrified has risen from 1000 to over 2400, the connected industrial load has more than doubled to 250MW, the irrigation and agricultural load has increased from 40,000kW to 100,000kW, and the total mileage of h.t. and l.t. lines has increased from 5000 miles in 1947 to 10,500 miles to-day. The agricultural pumping sets numbering about 5000 on the eve of independence are now nearly 22,000. About 15 per cent of the power is used for agricultural purposes, about 58 per cent for industry and mining, and the rest for domestic lighting, traction, &c.

Work on the Periyar scheme has recently been started and the Rs. 10-crore project will ultimately generate 100MW. Three additional schemes are awaiting the Planning Commission's sanction; they are the Kundah scheme, the Barapole project in Coorg and the Honnemaradu in Mysore. The Barapole is expected to develop 125MW in the first stage at a cost of Rs. 16 crores and to increase the capacity to 179.7MW in the second stage at an additional cost of Rs. 1·3 crores. The Honnemaradu project, one of the largest in India, contemplates the utilisation of waters of the Sharavati River in Mysore for generating about 400MW of power in three stages. Plans have also been made for extensions to Pykara and Papanasam schemes, each adding about 4000kW to existing capacities at a cost of nearly Rs. 3,000,000 to 4,000,000, per scheme. All in all, schemes involving a total installed capacity of 372MW have been proposed for inclusion in the second Five-Year Plan.

Even when the Periyar and the Kundah schemes are completed, the power available can only meet the existing demand. Moreover, the vagaries of the monsoons in these parts necessitate the "firming up" of hydro-power by the construction of more thermal stations. There is no coal in the south and the only comparable fuel is lignite which is still in the process of being exploited on an experimental scale, but it is understood that the pilot project is very encouraging and will probably lead to a number of lignite-burning stations. Initially, a thermal station with a capacity of 100MW is being planned, the project costing about Rs. 20 crores Much of this power will be utilised in mining and in industries which it is proposed to establish at Neiveli.

Maintenance Facilities for Diesel Locomotives

Two main works in the Eastern Region of British Railways have been scheduled for diesel locomotive maintenance as part of the modernisation plan. Doncaster is to be the diesel locomotive maintaining works for the North Midlands and the North-East, and Stratford for the London area and the South-East and East Anglia regions. On completion of the current diesel shunting locomotive plan, 204 of these locomotives will be based on Doncaster for works maintenance and 213 on Stratford.

At Doncaster provision of the new maintenance facilities will involve reorganisation in the tender bay of the new erecting shop and in the main boiler shop. The tender bay will be cleared of existing plant, some of which will be resited elsewhere in the erecting shop and some transferred to the boiler shop. The bay will then be re-equipped for the complete overhaul of diesel locomotives. Separate buildings are being provided to house the fuel injector repair equipment and the diesel locomotive load test tank and associated test equipment.

At Stratford works, part of the engine repair shop has been adapted to deal with intermediate and heavy repairs to both diesel-electric and diesel-mechanical locomotives. Provision has also been made for the servicing of fuel injectors in a portion of the inspection shop.

The total cost of the alterations carried out at Stratford and Doncaster is approximately £48,000. In addition, it is proposed to provide two regional stores, one at Doncaster and one at Stratford, in order to supply the out-stations and the main works with spares required for the repair of the diesel locomotives. At both works the alterations and modifications have been carried out by the chief mechanical and electrical engineer in conjunction with the chief civil engineer. They include the provision of shop stores, jib cranes, test tanks and associated equipment, battery-charging sets, injector servicing equipment and sump oil cleaning plants.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

POLYTROPIC EFFICIENCY

SIR,—Having just returned from holiday in Wester Ross, where, under the normal exigencies of the climate, one might expect to find a kelpie or water-horse at every burn, I find that your correspondent Mr. Woodrow (issue dated July 8th) has "sprung the kelpie" on your readers while I have been away from my desk. In other words, Mr. Woodrow's contribution appears as a kelpie in the subject matter of polytropic efficiency, and I hope no one has been carried away on this occasion. The kelpie, as legend has it, is supposed to carry its victim into the watery depths! Seriously, Mr. Woodrow fails to explain the connection between his expressions and polytropic efficiency and due to the shortness of his letter he does not give any expressions for the ratios, but leaves this to the reader.

Of the four expressions given we need only trouble ourselves with the last (*d*). This would appear to be a case with friction and heat flow, but such that all the friction occurs at the end of a frictionless polytropic. Now such a case is unlikely to exist as friction and heat flow will occur normally together. Herein lies the difficulty as it is not possible to separate out the friction heat (F) and the heat flow (Q), for the purpose of analysis. If Mr. Woodrow cares to take the general case, as he is attempting to do in case (*d*), say, for expansion with friction and flow of heat to the gas, he will find that he can obtain two expressions for the small stage efficiency, both yielding nearly equal values. The higher value is obtained when the heat addition is assumed to take place after the friction—one can assume a relation between F and Q by means of indices m and n.

Originally the writer had in mind only adiabatic cases, since it is conventional to neglect heat flow. However, the writer knows of at least one work where expansion with flow of heat was the specific study. The writer finds that his ideas are no way altered when it is necessary to consider heat flow as well as friction. I trust that Mr. Woodrow will give the subject further study.

EDWARD A. BRUGES

The University,
Glasgow,
August 10th.

SELECTION OF SENIOR STAFF

SIR,—A study of the histories of famous firms, and the biographies and obituary notices of the well-known engineers of two generations ago, leads one to the conclusion that much of their success was due to their ability to read character and thereby select first-class men for the more responsible positions on their staff.

It now seems that the "ability to choose" has become a lost art due either to a form of laziness on the part of directors or heads of departments, or simply to a lack of interest in the individuals on their staff.

This is evidenced by the growing reliance which is placed on "personnel managers," who for the most part are not trained engineers, are far too young, and are simply guided in their choice by the answers a candidate gives to questions on a standard "application form."

One cannot imagine a Parsons, an Adamson, a Day or an Allen, to mention a few of the old school, asking a candidate for a senior position how many children he had, the names of other relations, how many words per minute can he take down in shorthand, and even more personal and in some cases actually insulting questions. They would simply ask for proof of ability, soberness and integrity; and in actual fact, in some cases, would not even ask for such proofs, but relying on their own judgment would say "Start on Monday."

It is fairly well recognised that the ability to pass examinations is not an entirely satisfactory proof that a man is a good administrative engineer, and it is highly probable that the man who is good at examinations will make the most of a "questionnaire."

The question is of considerable importance, as much of the waste and mismanagement which goes on in many works to-day is attributable to the fact that the executives have been chosen on their "paper qualifications," and furthermore, having become simply cogs in the organisation, their capabilities (or lack of same) are not known to the heads of the concern with the result that many first-class men are leaving the industry or have become so apathetic that they have taken junior or lower-grade positions where their abilities are completely wasted.

CHARLES D. M. KEYWORTH,
A.M.I.Mech.E.

Paisley, August 12th.

RINGELMANN CHARTS

SIR,—The short article on Ringelmann Charts in THE ENGINEER of August 5th contains one or two statements which might be misleading to your readers. The first point we would comment on is the implication in your note that the Ringelmann Charts, in the form published by us, contain the solid black square ("Shade 5"). Nowadays only Shades 0 and 1 to 4 are used, since it is very unlikely that completely black smoke would now be found.

Again, your note refers to the inconvenience of the cards having to be held up by another person to enable a reading to be made. In fact, we recommend that the chart should be mounted on a board and suitably fixed so that frequent checks can be made of smoke density in any particular case (as will doubtless be necessary when the provisions of the "Clean Air Bill" become law), and we think this could normally be arranged without much difficulty. It is true that the Beaver Report refers (in Appendix V) to this possible disadvantage, and to research now being carried out on methods of overcoming it. But the report does go on to say that according to tests carried out by the Fuel Research Station, the use of our chart gives more consistent results than a reduced form of chart which is popular in the U.S.A.; and it might be added that the report (Section 95) comes down in favour of visual methods of estimating smoke density, as against measurement by instruments. We conclude that our own version of the Ringelmann Chart is recommended simply because, for everyday use, no more reliable and practical method has so far been devised.

C. F. RAE GRIFFIN,
Managing Director
Charles Griffin and Co., Ltd.,
London, W.C.2.
August 15th.

Literature

Bessel Functions for Engineers. By N. W. MCLACHLAN. Second edition. London: Oxford University Press, Ltd., Amen House, Warwick Square, E.C.4. Price 35s.

BESSEL functions are named after the German mathematician and astronomer, Fredrich William Bessel, who was director of the observatory at Königsberg. He obtained them as solutions of a differential equation resulting from a problem in elliptic planetary motion. This was in 1824. They have since been found to arise in the practical problems of many branches of engineering. In structures they occur in problems associated with the buckling of columns; in acoustics, the vibration of membranes and loudspeakers; in heat, temperature distribution in engine walls and heat flow; in hydraulics, water flow and oscillations of water; in electricity, eddy currents and transmission lines. These are but a few examples of the widespread applications of these important mathematical functions.

In 1934 the first edition of Dr. McLachlan's *Bessel Functions for Engineers* was published. As its name implies, it was written not for the mathematician, but primarily for the engineer. It has established itself among engineers as the standard book on the subject and has thoroughly justified its title. In this second edition the text has been rewritten and the scope extended. The same technique has been followed throughout the book; giving applications of the mathematics to the solution of practical engineering problems, with worked examples to illustrate the methods of solution. Despite this practical aspect, the mathematics itself is sufficiently rigorous—more so than in the first edition—to satisfy engineers who are applied mathematicians.

The first chapter gives a short historical introduction and covers Bessel functions of the first three kinds, but confined to zero order; the second chapter extends the treatment to higher orders. There follows a chapter on expansions and integration. It includes formulæ for the expansions of cos ($z \sin\theta$) and sin ($z \sin\theta$) as a series of Bessel functions. The radio engineer will recognise these expressions as giving the amplitudes of the side bands in the spectrum of a frequency modulated wave. This practical application is, however, not specifically mentioned.

Chapters are devoted to Struve functions and to modified Bessel functions. Integrals for the product of two functions, the introduction of the complex variable and the derivation of asymptotic expansions of the various functions are included. The latter is particularly important owing to their use in approximate solutions.

The final chapters cover the ber, bei, ker,

kei, and other kindred functions with their applications. These include such practical problems as the eddy current loss in a cylindrical conductor. Approximate answers can be obtained in terms of trigonometric and hyperbolic functions ; but the exact solution to these and many other problems can only be obtained by the use of Bessel functions.

There are three appendices : Gamma and Hypergeometric Functions, Convergence, and Singularities and their Solution. There are a number of problems at the end of each chapter and a miscellaneous collection at the end of the book. A list of the symbols used is at the beginning : 327 formulæ and thirty tables of functions are given at the end. This is followed by a bibliography of 136 references, grouped by subjects.

Dr. McLachlan has produced a very comprehensive book on Bessel functions. By his clear expositions and practical illustrations he has removed a great deal of the difficulty from the subject. Starting from first principles and proceeding logically, it constitutes an admirable textbook for the advanced engineering student. For the research or graduate engineer who has occasion to make use of these mathematical functions in their many applications, it provides a valuable reference book.

Manufacture and Application of Lubricating Greases. By C. J. BONER. London : Chapman and Hall, Ltd., 37, Essex Street, Strand, W.C.2. Price 148s.

THE subject of lubricating greases has never received much attention from publishers, presumably because it has only been of interest to a limited number of specialists who share the invidious task of manufacturing and applying this versatile type of lubricant in a thousand and one ways. The only other comprehensive work on lubricating greases, by Klemgard, was also published by Reinhold in its final edition in 1937, and in the subsequent seventeen years a considerable amount of research and development in lubricating greases has taken place. We should therefore be grateful to Mr. Boner and the Reinhold Publishing Corporation for bringing us up to date with this new work, which covers the period from 1937 to 1952.

The new book adopts the same format and style as its predecessor and largely covers the same ground. After an introduction dealing with the importance of greases as lubricants, there is a useful review of the fundamental work which has been carried out, mostly during the last ten years, on the structure of lubricating greases. The following chapters systematically, and in some detail, deal with the raw materials and additives used in the manufacture of greases. Manufacturing processes are dealt with thoroughly, as also is the manufacturing equipment used. It should be noted here, however, that everything said on this subject is based on American experience, which is perhaps only natural in view of the author's position as chief research chemist to the Battenfeld Grease and Oil Corporation of Kansas City, Missouri.

Lubricating greases are conventionally classified according to the metal components of the soap used as the thickener of the oil, and succeeding chapters in the book competently describe the greases made from aluminium, barium, calcium, lithium, sodium and strontium soaps. A short chapter is devoted to other less important greases which have been made from such metals as beryllium, cadmium, cerium, cobalt, &c. Of these, lithium greases were unheard of in 1937, but the importance of this comparatively new kind of grease is shown by the fact that the chapter devoted to it is as long as the chapter on sodium greases and about the same number of literature references are given for both.

Other new kinds of grease which have been developed since Klemgard wrote his book are mixed base greases, i.e. greases made with soaps derived from more than one metal, complex soap greases, and non-soap greases. The last two kinds of grease have each received as much attention as lithium and sodium greases, both from Mr. Boner and from the authors of papers and patents. They have been developed in order to meet extreme operating conditions, and provide an interesting field for future fundamental research on grease structure. In the conventional greases the soap exists in the form of fibres, and nearly all of the fundamental research on grease structure has so far been confined to this kind of system. Complex soap and non-soap greases, however, do not contain fibres, and it is difficult to understand how the thickeners perform their function. The main thickeners used in non-soap greases are silica and clays, and it is an interesting thought that one of the modern trends is to produce an excellent lubricant by suitably mixing together sand and oil !

As already indicated in this review, Mr. Boner's book concentrates largely on the manufacturing aspects of lubricating greases. The application of lubricating greases is dismissed in the eighty pages of the concluding Chapter 21, of which about twenty pages deal with dispensing equipment. We fear that the grease user will find little to satisfy him in this book, but it will be an invaluable source of information and reference guide to the grease maker. In this respect Mr. Boner makes no attempt to analyse critically the published data in order to form his own conclusions. On the other hand, he quotes extensively from his sources of information and provides a well-balanced review of the published work on lubricating greases. He restricts himself, however, almost exclusively to North American and British literature, and the book is obviously written for the American grease manufacturer.

Gas Turbines for Aircraft. By I. H. DRIGGS and O. E. LANCASTER. New York : The Ronald Press Co., 15, East 26th Street, New York, 10, U.S.A. Price 10 dollars.

THIS American book follows the familiar pattern of a large slice of theory garnished with a dressing of photographs and "popular interest" material. In the present offering the fare is arranged as a sandwich, the "filling" of theory being flanked at the beginning by an illustrated chapter on rocket and ramjet as well as gas-turbine propelled aircraft and at the end by another on the history of the subject. Why authors swell the number of pages and, more regrettably, the price of their books with such hackneyed and dating information is something of a mystery!

The theory opens with a chapter on fundamentals consisting mainly of a concoction of elementary mechanics and thermodynamics. This is followed by cycle analysis which shows, by example, methods of calculation based on the enthalpy-entropy chart. The analysis is confined to ideal cycles, the effect of losses being postponed to a later chapter and there is no indication of the effect of such important design variables as pressure-ratio and turbine-inlet temperature on cycle performance. The work continues with a useful summary of elementary compressible flow theory and some sketchy and quite inadequate accounts of compressors, turbines and combustion. It is in the remaining chapters on engine and aircraft performance and control problems that the authors are obviously on their most familiar ground and here present a full account of these topics based largely on their own publications.

The text is clearly presented and the chapter summaries are commendable. The absence of numerical answers to the problems collected at the end of the book detracts much from their value to the serious student. For those who are well versed in the fundamentals of gas turbine technology and have special interests in the performance and control problems of turbine driven aircraft, the book may have some value although its claim to be a comprehensive reference volume for aeronautical engineers is hardly justified.

The Commissioning of Electrical Plant and Associated Problems. By R. C. H. Richardson, B.E., A.M.I.E.E. Third edition. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 50s.—This book forms the fifth volume of a series of monographs on electrical engineering. It was first published in 1938 with the object of giving the reader information that has been found useful in the commissioning of a.c. and d.c. generating, transforming and converting plant. For the second edition, published in 1945, the material was revised and space was found for new material partly by the expedient of omitting some of the more theoretical aspects of the subject about which information was available elsewhere. A new section on the commissioning of circuit breakers was added, and the bibliography was extended. Further revision was undertaken for the third edition and each section of the book was brought up to date.

"*L'Interpolation Idéale et son Calcul Numérique Effectif.*" By Pierre Venotte. Publications Scientifiques et Techniques du Ministère de L'Air, No. 300. Paris : Sdit, Magasin C.T.O., 2, Avenue de la Porte-D'Issy, Paris (15e). Price 850 fr.—This book is based on a lecture given in May, 1953, before the Numerical Calculations Group of the Centre Nationale de la Recherche Scientifique. The author considers an interpolation as "ideal" if its form is not affected by a transformation. Provided the given sequence of data possess a sufficient degree of regularity, new values can be interpolated at mid-intervals of the independent variable, and so on, as far as may be required. One seeks a solution of the same regularity as the original data, as shown by the signs of successive differences. Provided the function does not grow too rapidly, it is sufficient for carrying out the calculations to have a recurrent relationship between successive terms of the given sequence, which must also be regular. Nevertheless, it is shown that the condition of "regularity" is by itself sufficient. A number of numerical examples serve to illustrate the method.

A Handbook of Hard Metals. By W. Dawihl. London : Her Majesty's Stationery Office, York House, Kingsway, W.C.2. Price 25s.

Mathematics for Engineers. Part I. Ninth edition. By W. N. Rose. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 21s.

Centrifugal and other Rotodynamic Pumps. Second edition. By Herbert Addison. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 50s.

Q. and A. on Surveying and Levelling. By R. H. Gould. London : George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 6s.

How Time is Measured. By P. Hood. London : Oxford University Press, Amen House, Warwick Square, E.C.4. Price 10s. 6d.

Diesel Engine Principles and Practice. Edited by C. C. Pounder. London : George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 84s.

Metals Reference Book. Second Edition. In two volumes. By C. J. Smithells. London : Butterworths Scientific Publications, 88, Kingsway, W.C.2. Price 88s. per set.

Exhibition of Peaceful Uses of Atomic Energy at Geneva

No. III—(*Continued from page* 230, *August* 12*th*)

AS stated in a previous article (August 5th, page 190), several models of nuclear reactors are being shown by the U.K. Atomic Energy Authority at the two exhibitions running in conjunction with the international conference on the peaceful uses of atomic energy in Geneva. The conference and the exhibitions close to-morrow.

Calder Hall, which will be Britain's first power station to generate electricity on an industrial scale, is represented by exhibits both at the Palais des Nations and at the Palais des Expositions. The Calder Hall reactors, which are referred to in Sir Christopher Hinton's paper,* consist of two graphite-moderated pressurised gas-cooled piles. Each of these reactors has a core surrounded by an octagonal concrete biological shield several feet thick, protected by a thermal shield of 6in mild steel plate. Induced draught air cooling is supplied to the space between the two shields, the air being exhausted 200ft above ground level.

The graphite moderator, weighing over 1000 tons, is contained in a cylindrical pressure vessel. The machined graphite blocks have vertical uranium charge and control rod channels and are supported on a "diagrid" structure consisting of an I-section ring girder spanned by steel beams forming a rectangular lattice. The pressure vessel is about 40ft in diameter and 60ft high, and is of 2in welded steel plate.

Facilities for reactor charge and discharge are accommodated on the vault roof, along with the control and shut-off gear. The control rods and shut-off rods are of stainless steel tube lined with boron steel fillers.

The hot carbon dioxide coolant is led away from the top of the pressure vessel by circular mild steel ducts of 4ft 6in diameter to the four heat exchangers at the corners of the pile building. Over 20 tons of carbon dioxide are required to complete the filling of the reactor and coolant circuits.

Each of the four heat exchangers is contained in a vertical steel pressure shell of 1⅝in steel plate. They are about 18ft in diameter and some 70ft high. The 30,000 square feet of water heating surface, comprising high-pressure and low-pressure economiser, evaporator and superheater sections, is made of 2in overall diameter mild steel tubing, through which the water and the steam pass. A dual-pressure steam system drives the two-cylinder reaction turbines of the four 3000 r.p.m. air-cooled turbo-alternators which have a full-load rating of 23MW at 11kV.

A separate "dump" condenser is provided in which up to the full-load steam production of the heat exchanges may be condensed without passing through the turbines. A closed circuit cooling water system is employed for the condensers. Cold water at about 21 deg. Cent. is fed from the cold pond to the section basin, where four electrically driven pumps circulate the water to the condenser battery. The hot water at a design temperature of 30 deg. Cent. is fed to the sprays in two natural draught cooling towers, whence it returns to the cold side pond. The cooling towers are somewhat larger than normal, being 290ft high and 220ft in diameter at the ring beam. Each is capable of cooling 3,000,000 gallons of water per hour by 10 deg. Cent. Models of the No. 1 reactor and of the turbine hall are displayed at the Palais des Nations.

One of the exhibits at the Palais des Expositions is a model of the site at Dounreay on the north coast of Scotland, where work has recently started on a reactor of an experimental and advanced design—a fast fission "breeder" reactor, cooled by liquid metal. This project is described in a paper presented to the conference by J. W. Kendall and T. M. Fry.

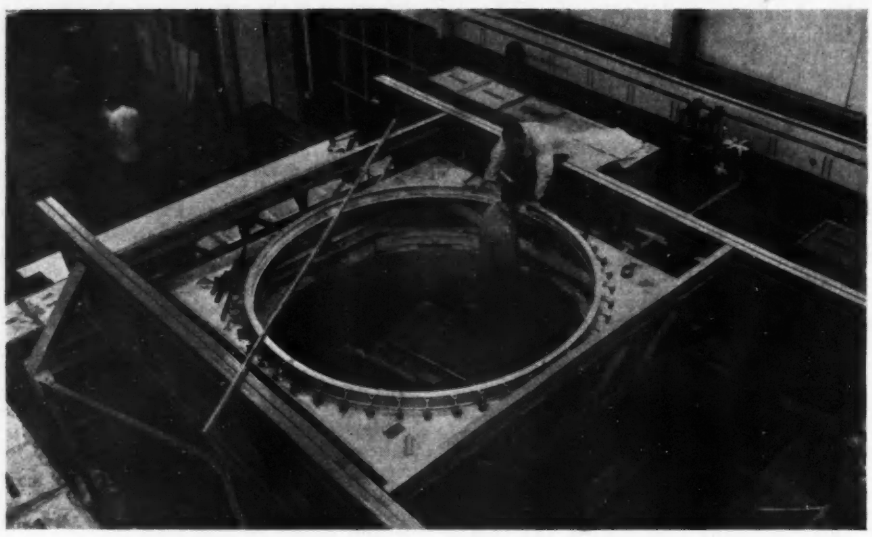


Fig. 15—Dimple heavy water reactor under construction at the Atomic Energy Research Establishment, Harwell. The aluminium tank, and part of the graphite reflector outside it, can be seen

Dounreay is an experimental project with the aim of demonstrating the feasibility of generating industrial power with fast reactors. To allow for developments in core design, the plant is being made in the form of a shielded pot, through which sufficient liquid sodium or sodium-potassium alloy can be pumped to extract 60MW of heat. All the contents of the pot will be removable.

To ensure a reliable supply of coolant the primary circuit will be completed by twenty-four branches transmitting heat to independent secondary liquid metal circuits. Each branch will incorporate an electro-magnetic pump. The primary circuit will be made from stainless steel to give high-temperature strength and to simplify circuit cleaning. It will be butt welded with radiographic inspection throughout, following the techniques found satisfactory for the plutonium separation plant at Windscale. There will be no valves or glands below the free surface of liquid metal. The pumps will be grouped in pairs with independent electrical supplies to avoid the possibility of simultaneous failure. Each secondary circuit will be followed by a steam generation circuit and a sea-water-cooled condenser. To avoid activation of the secondary coolant, the pot will be surrounded by a neutron shield. It will be closed at the top by a thick plug, mechanically sealed during operation.

The heat exchangers will occupy an enclosure, maintained hot enough to keep the coolant molten, inside a concrete biological shield consisting of a bowl 90ft in diameter and 45ft in height. The concrete structure will support the pot, neutron shield and heat exchangers.

The reactor will be enclosed in a steel sphere to safeguard the district in the event of an accident which might release radioactivity. The reactor sphere, which will be 135ft in diameter, has been designed for a maximum internal pressure of 17 lb per square inch and a maximum external pressure of 4 lb per square inch, which are considered to be the worst conditions to which it might be subjected. The possibility of an explosion due to run-away of the nuclear reaction can be ruled out in the design of the core and the control system. Water will be excluded from the sphere and the concrete will be jacketed to prevent contact with sodium. The remaining source of pressure rise might be the reaction of sodium with the air inside the sphere. This reaction could only take place as fast as the sodium could be vaporised by the shut-down heat from the reactor, and under such conditions it is estimated that heat transfer from the air to the pressure vessel would limit the pressure rise.

Research Reactors of the U.K. Atomic Energy Authority

Models and drawings of a number of research reactors, completed, under construction or projected, are also on show.

"*Dido*," *High-Flux Research Reactor*, *E*.443.—A new high-flux reactor for experimental work, including tests of fuel and coolant systems, is being built at the Atomic Energy Research Establishment, Harwell; when complete by the summer of 1956 it will have the highest neutron flux in Western Europe.

"Dido" is a heavy-water-cooled and moderated reactor using an alloy of enriched uranium and aluminium as fuel; it is designed for a maximum thermal neutron flux of $10^{14}n$ per square centimetre per second at a total heat output of 10,000kW.

It will be used for a variety of purposes, such as: study of the effects of radiation on materials including behaviour of reactor fuel elements; fundamental measurements

* "The Graphite Moderated Gas-Cooled Pile and Its Place in Power Production." Geneva, August 16th.

in nuclear physics ; production of radio isotopes of high specific activity ; experiments involving small pilot fuel and coolant systems.

The research facilities are designed round a heavy-water-cooled and moderated core consisting of twenty-five multi-plate fuel elements arranged in boxes to form a cylinder of 86cm equivalent diameter and 60cm long. These fuel elements consist of enriched uranium-aluminium alloy rolled between sheets of high-purity aluminium to form a welded sandwich ; the components forming the completed unit are brazed together.

The heavy water coolant flows upwards between the plates, the large surface area of these and the small coolant channel cross-section enables considerable quantities of heat to be removed with small temperature differences. Curvature of the fuel plates ensures that thermal expansion is taken up in one direction only and does not reduce the coolant gap.

The core is surrounded by a heavy water reflector and the whole contained within a sealed aluminium tank of 3m diameter and 2m height. A further graphite reflector, 60cm thickness, surrounds the core container to provide additional experimental volume. Heavy water is circulated by means of totally enclosed pumps and motors of special design, through the fuel elements and then through stainless steel tubular heat exchangers which, in turn, dissipate the heat via a secondary water system to atmosphere through induced-draught cooling towers. The reactor is contained within a steel dome to prevent the escape of any activity that might result from an accident to the reactor or experimental equipment.

Very extensive research facilities are provided. Altogether, there are sixty separate experimental openings through the biological shield. The more important are a graphite thermal column 5ft by 5ft, horizontal holes penetrating the maximum flux zone from 4in to 10in diameter, vertical holes penetrating the maximum flux zone from 2in to 6in diameter, numerous other holes penetrate the graphite, including two 12in by 8in holes right through.

Main Particulars of "Dido" High Flux Research Reactor E443

Maximum thermal flux	$10^{14}n$ per sq. cm per sec
Total heat output	10,000kW
Heavy water investment	10 tonnes
U235 investment	2½kg
Heavy water circulating rate	22 tonnes per min
Secondary cooling water circulating rate	24 tonnes per min
Make-up secondary water quantity	370 tonnes per day
Power consumption of reactor including instruments and experiments	1200kVA

The design and construction of this reactor and its associated equipment is being undertaken jointly by the Ministry of Works and Head, Wrightson Processes, Ltd., under the direction of the Atomic Energy Research Establishment, Harwell.

"Pluto" High Flux Materials Testing Reactor, R.E.775.—Constructional work has also started on two new testing reactors for the Authority. These reactors will be of the same basic design as the research reactor E.443. Each will operate at a maximum neutron flux of $10^{14}n$ per square centimetre per second, and a total heat output of 10,000kW.

They are being built for the development and testing of new kinds of fuel elements, reactor components and for investigations into problems associated with coolants, such as corrosion, mass transfer, coolant decomposition and continuous chemical reprocessing. It is planned to operate up to six major loops in each reactor, each loop being a pilot model of the essentials of a future reactor system.

The research and experimental facilities to be provided are as follows :—

Size	Number off	Position
7in diameter	4	Horizontal through heavy water reflector near fuel
7in diameter	4	Vertical into heavy water reflector near fuel
4in diameter	4	Vertical at mid radius of heavy water reflector
4in diameter	6	Vertical into graphite reflector

"Dimple" (Deuterium Moderated Pile, Low Energy).—"Dimple" (the first heavy water pile to be completed in Great Britain) is a zero-energy heavy-water-moderated reactor which is used for fundamental reactor physics research. Its main characteristics are that any desired configuration of materials can be used to form the reactor ; that changes in reactivity of a particular configuration can be achieved by altering the size of the reactor ; and that many regions of the reactor are accessible to experimental equipment. "Dimple" is contained in an aluminium tank 8ft 6in in diameter and 10ft 2in in height (Figs. 15 and 16). Aluminium grids can be placed inside that tank to support and locate the reactor materials. A similarly designed aluminium grid provided with seals acts as a lid to the tank and suitable access can then be obtained through this lid. The tank is connected to two storage tanks from which the moderator can be pumped. A second pump is used to control the reactor by varying the level of the liquid ; this pump is variable in speed and reversible. The storage tanks are below ground level so that the reactor tank can be emptied by opening "dump" valves. Two sets of safety rods are installed.

The reactor tank is supported from the top so that a reflector up to 3ft in thickness can be placed beneath it. The tank is enclosed in a concrete shield but sufficient space is left to install and remove a radial reflector of up to 3ft in thickness. The concrete at the top of the reactor is carried on two removable trollies so that access can be obtained to the reactor tank lid. Reactor power is limited to a few watts so that the reactor material can be handled after operation and no cooling is therefore required.

Examples of measurements which can be carried out are : basic measurements in a variety of possible reactor designs to ascertain the critical geometry, flux distributions and the various neutron origins and fates ; pile oscillator measurements in a variety of neutron spectra varying from an internal thermal column to the use of hollow fuel elements ; effect of large perturbations on flux distribution and reactivity.

"Zephyr" (Zero Energy Fast Fission Reactor).—"Zephyr" (Fig. 17) is the first fast reactor to be built in Britain. It consists essentially of a core of plutonium surrounded by an envelope of natural uranium. The core forms a right cylinder about 15cm in length and diameter, the plutonium being in the form of rods canned in nickel which are mounted vertically in an equilateral array in a suitable matrix. The envelope of the reactor consists of about 8 tonnes of natural uranium which is also in the form of a right cylinder situated around the core. Control of the system is achieved by movement of sections of the uranium envelope in the vicinity of the core, thereby varying the neutron leakage into the envelope. The normal (fission) power of the reactor is 2W, for which no cooling is required.

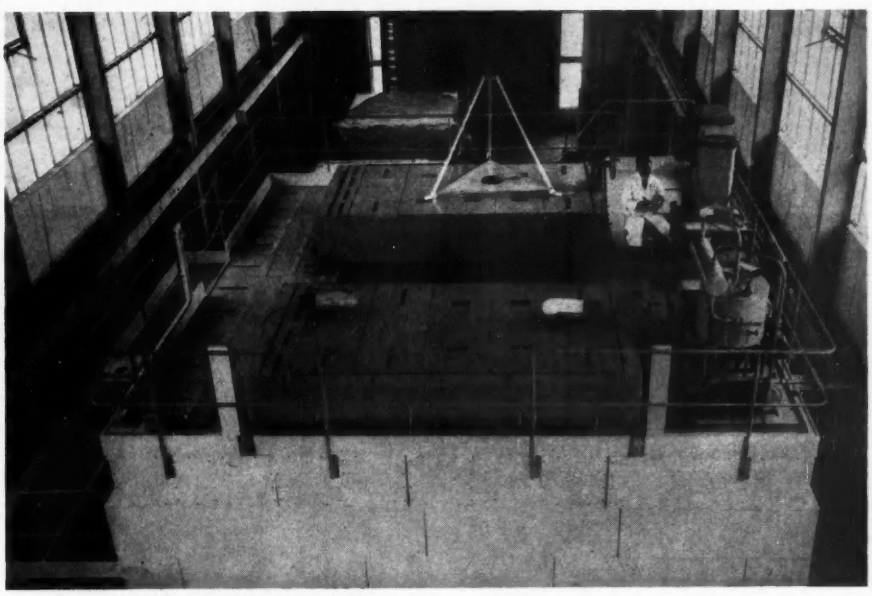


Fig. 16—The completed "Dimple" reactor, showing the controls and the removable concrete blocks forming the top and side shielding

It was announced on August 9th that a ratio of plutonium breeding to plutonium consumption of 2 : 1 has been achieved with "Zephyr."

"Zeus" (Zero Energy Uranium System).—"Zeus" is a full-scale zero-energy version of the fast reactor which is to be built at Dounreay. "Zeus" will be built at Harwell and will be used for the study of neutron characteristics, critical conditions and control calibrations of the projected power reactor.

The core of "Zeus" is an assembly of vertical tubes containing pellets of highly-enriched uranium (40 to 50 per cent U.235) mixed with natural uranium pellets, the mixture ratio being variable. An envelope of natural uranium in the form of vertically-mounted rods, surrounds this core. Control of the reactor is by movement of groups of dual elements near the boundary of the core and as the maximum power level is only 100W, no coolant is required.

Heavy Water Reactor at Dounreay.—A new project announced by the U.K.

Atomic Energy Authority is the building of a heavy water research reactor at Dounreay, in addition to the fast breeder power reactor which is to be sited there. It will be similar to the heavy water pile " Pluto " at Harwell and will be accommodated in a steel cylinder 70ft high and 70ft in diameter, with a domed top. It is to be designed for research work and not for electricity production.

An Industrial Design for a Research Reactor

Some details have been given at the Palais des Expositions of a design for a research reactor which has been prepared by the A.E.I. and John Thompson Industrial Nuclear Energy Group, of Oak House, Cross Street, Sale, Manchester.

This design relates to a water-moderated reactor with facilities for experimental work on a variety of subjects, including cross section measurements, neutron diffraction, exponential studies, engineering materials testing, irradiation damage in materials, shielding studies and food sterilisation by radiation.

The power level of the reactor is stated to be 1MW for five to ten hours or 100kW continuously. At 100kW the peak fluxes in the core are given as: thermal neutrons, about $0{\cdot}15\times10^{12}n$ per square centimetre per second; epithermal neutrons, about $6\times10^{12}n$ per square centimetre per second; gamma radiation about 10^7r. per hour.

The reactor core is moderated and cooled by light water and the reflector arrangement permits the use of various alternative materials. To accommodate the large number of experimental tubes, the core is arranged to occupy any one of three vertical positions, the tubes and thermal columns being distributed among these three positions to utilise the available space to the full. Both the concrete shield and the water depth have been designed to afford adequate shielding at all the working positions, including the open top of the reactor. The experimental tubes are provided with suitably designed plugs to obviate excessive radiation when they are not in use. The outer face of the concrete shield includes a steel framework and individual steel plates to facilitate the mounting of experimental apparatus adjacent to the beam tubes.

The core is cooled by circulation of the water used as the moderator. This water may be circulated through a water/water heat exchanger, the secondary circuit being cooled by a mechanical-draught cooling tower or local water supply; alternatively, the primary water may be cooled in an air blast cooler. To confine the hot water path through the reactor, the core is surrounded by an aluminium flume which extends from the base of the tank to an upper position where the hot water is drawn off for recirculation. At the same time, some of the bulk water is also drawn off, cooled and recirculated, to hold its temperature at a reasonable level. The inlet to the flume is so designed that in the event of failure of the forced cooling circuit, there will be an appreciable circulation of water by natural convection, thus safeguarding the core after shut-down. The primary water is demineralised by hydrogen ion exchange equipment, and purity is maintained by continuous by-pass recirculation through the demineralisation plant and by intermittent filtering. In this way the induced activity in the water is reduced to a negligible amount.

The core and reflector assembly consists of small sections supported in a framework. The sections are individually removable by means of a simple loading rod which enables this operation to be done at the working depth in the water. Suitable mechanical interlocks are provided to prevent any error being made during loading and unloading. The individual elements can be stored in any of forty-eight storage holes which are situated within the bulk shield. The storage holes are adequately shielded to allow access to the inner tank when the core and its framework have been removed. The holes will also hold control rods and small irradiated samples prior to their removal in a suitable coffin.

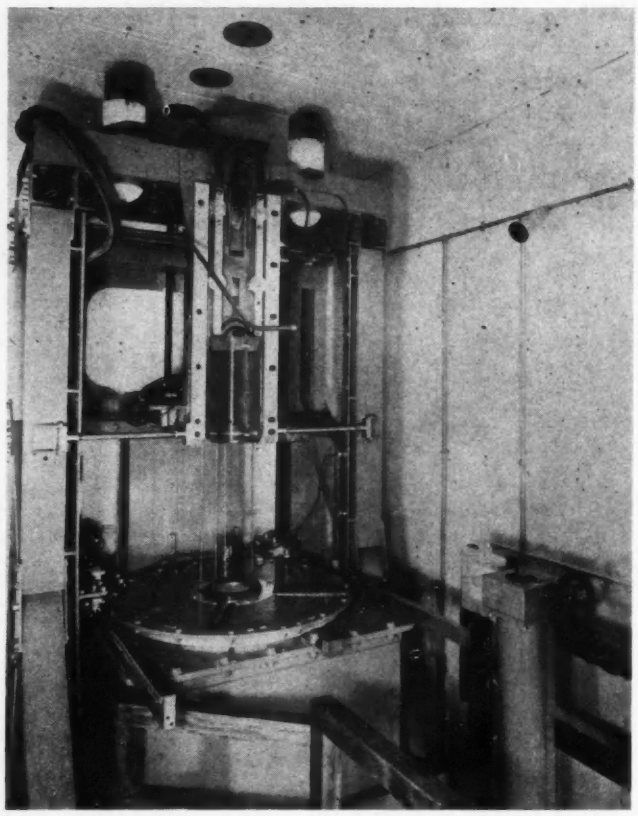


Fig. 17—" Zephyr," the zero-energy fast reactor at Harwell. The top uranium reflector is shown raised exposing the reactor core in the centre of the circular top plate of the tank

Six groups of experimental facilities are provided in the design: two thermal columns with external faces 4ft 6in square; a shelf to take a canned experiment occupying a space of at least a 2ft cube; a 3in by 3in hole vertically through the centre of the core; six 12in diameter holes and six 6in diameter holes, each ending as close as possible to the reflector face; five 6in diameter holes passing right through the reactor and parallel to a reflector face, for use in " rabbit " experiments, and four 8in vertical holes specially for chemical experiments.

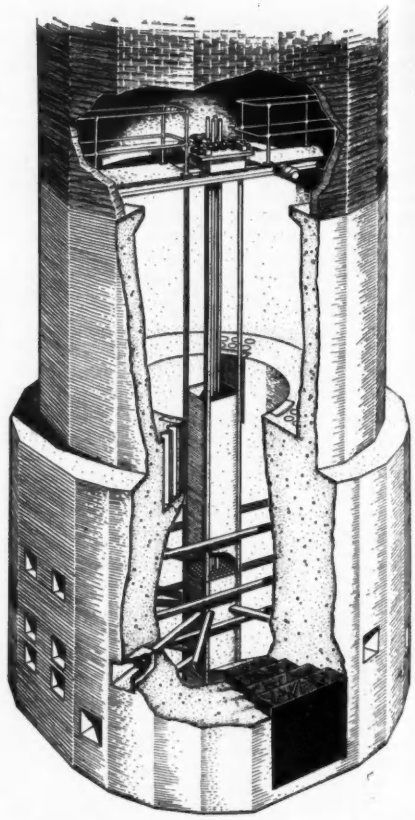


Fig 18—Sketch showing typical layout of a proposed water-moderated research reactor

The reflector area is divided into sections about 3in square, most of which can be made available for irradiation experiments by substituting a suitable canned specimen for the reflector section. Each of the beam tubes can be removed from the outside of the shield so that some modifications can be carried out without major shielding precautions.

The core is protected by two safety rods and two control rods—one coarse and one fine. All the rods will enter the core under gravity and are controlled from a position vertically over the core above the water level. The coarse control rod is of sufficient capacity to shut down the reactor in an emergency. The fine control rod and associated control system ensure stability of the flux level during operation. Interlocks and safety circuits are provided so that in the event of maloperation or unusual circumstances the coarse control rod will drop. Failure of this rod to operate correctly is safeguarded by the two safety rods. Four ion chambers are situated at the corners of the core and a fission chamber at the core centre. Adequate instruments are provided to start up and shut down the reactor and to observe flux levels, water activity, tolerance levels round the reactor and water temperatures during running. These instruments and controls can usefully be installed near the top of the reactor, but can, of course, be in any position most convenient for operation.

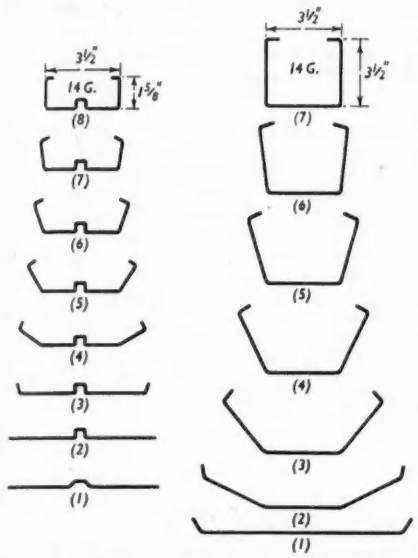
The automatic control system for the fine control rod is designed to maintain the flux level at full power to an accuracy of ±1 per cent during operation.

(*To be continued*)

Manufacture of Cold Formed Structural Sections

A recent use of cold-formed steel for structural work was discussed in our issue of June 3rd last. A description of a braced portal structure evolved by Metal Sections, Ltd., was then given. Here we describe the manufacture of the structural components.

IN our issue of June 3rd last, we published a description on page 776 of some single-storey storage buildings, the structures of which comprised three-pinned braced portal frames, fabricated from cold-formed steel strip. On that occasion we illustrated the various boom sections, incorporated in the portal, made from 14 to 10 gauge strip ; the basic section was formed as an open box, and where additional strength was needed, one, two or three stiffeners were welded to its interior. A smaller box section was used for bracing members, and a latticed purlin, comprising two lipped channels connected by tubular cross bracing, was also utilised. Half-portal frames were delivered to the site in two parts, and a bolted joint at the knee was then made, prior to erection. Some further details are given here of the method of manufacturing these cold-formed portal frames, as carried out by Metal Sections, Ltd., at its works at Oldbury, Birmingham. The manufacturing process can be subdivided into four main groups, namely, (*a*) rotary gang slitting, (*b*) cold forming, (*c*) assembly, and (*d*) finishing. Our description is taken from a recent paper by Dr. Harvey and Mr. Griffin, presented to the Midlands Section of the Institution of Structural Engineers.



Stages in the cold rolling of structural "box" sections. A bracing member for the portal frame is shown on the left, and the basic boom on the right

Rotary Gang Slitting.—The rotary gang slitter consists of a decoiling drum or cable, a rotary slitting head and a recoiler. The wide coil is mounted on the decoiler, unwound either by hand or flattening rolls, fed into the slitting head and subsequently recoiled on the recoiling drum. This drum is generally collapsible. After recoiling and banding around the circumference the drum is collapsed and the coils removed.

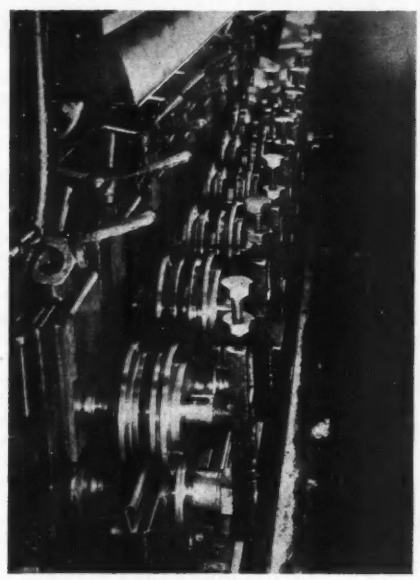
The earliest rotary slitters were designed primarily for slitting sheets and thus consisted of a driven slitting head, feeding, and taking out tables. For gang slitting, the slitting machines were modified to include decoiling and recoiling stands. This innovation brought many difficulties mainly due to the need for synchronisation of the slitting head and recoiling drum speeds. In modern plants this has been accomplished with slipping clutches and variable speed d.c. motors, either manually or automatically controlled. Another answer to this problem has been the design of the "pull through" slitter. This machine has a slow speed drive on the slitting head for the initial length of strip until the strands are fed on to the recoiler. The recoiler then takes over the drive at a much faster speed The slitting head has an "over-run" clutch in its drive and thus becomes an idler.

Cold Forming.—After the coils have been slit to the required width, they are transferred to the decoiling stands of the roll-forming machines. The strip is then fed through flat guides into the first stage of the forming operations, by hand. The first stage generally consists of flat or slightly domed forming rolls, that are set with sufficient pressure to grip the flat strip to drive it forward through the progressive stages of the forming operation. When the strip has passed through several stages these drive rolls can then be lifted. This is essential as any excess pressure on the strip tends to influence either the shape of the cross section or the straightness of the sections.

In the design of the forming rolls the roll designer must be constantly aware of the many factors which tend to influence the rate of forming and the number of stages involved. Such factors include the machine capacities, shape of finished section, strip material to be used, and also the tolerances required on the finished profile.

The number of stages and rate of forming of two typical structural sections are shown in the first illustration ; the left-hand section is the bracing member of the portals referred to above, and the right-hand section is the basic "box" section, to which stiffeners may afterwards be added. A typical cold forming unit and a close-up of the partially formed material passing through some of the stages are also illustrated.

The sections are rolled along shallow trays up to 80ft in length, cut off by cold saw at the end of the forming machine and transferred to stillages ready for cutting with power presses or power saws to the required lengths. These stored long lengths are generally multiples of the lengths required for the structural members.

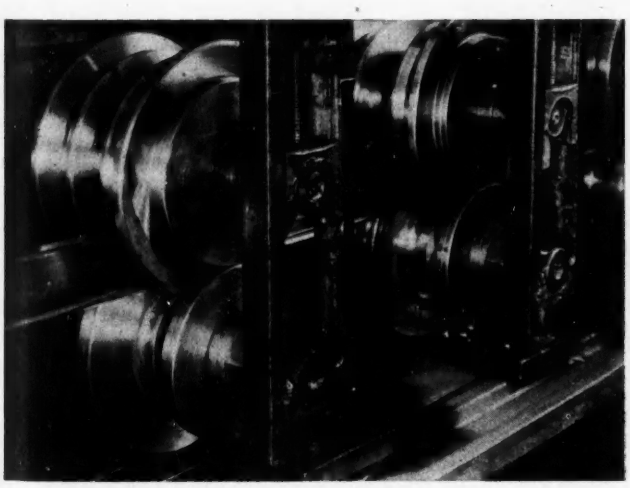


A typical installation of cold forming rolls, in which a strip of steel is shaped, stage by stage, is shown here

General commercial limits on cold-formed sections are ±0·010in on shape L/300 straightness and $\pm^1/_{32}$in on length.

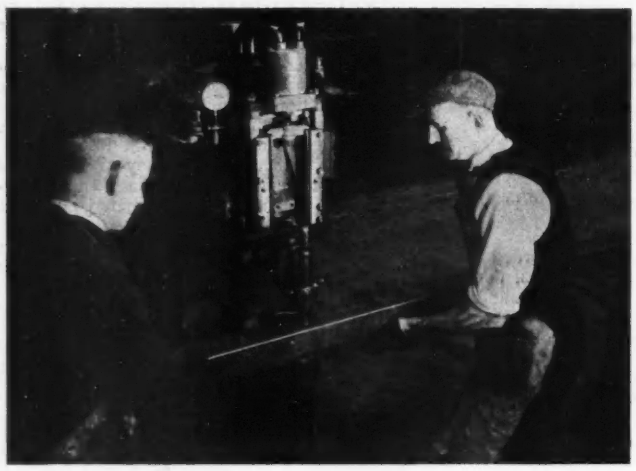
Where sections have a very wide width of strip, simple in shape, but beyond the capacity of the roll-forming machines, then cold forming can be carried out on press brakes. This method is also ideal for limited quantities or short lengths of simple shapes as standard air brake dies can be used to produce a profile in a series of bending operations.

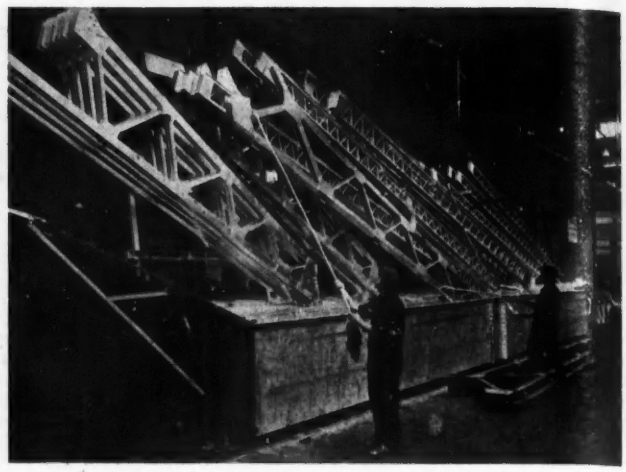
Assembly.—After rolling and cutting to lengths



Two stages of the rolls used in forming a "box" structural section by cold rolling

Assembly of 20ft braced purlins, with light alloy assembly jig and spot welding machine





Welding a stiffener to the "box" section boom is here shown in progress. Right, painting the completed structural members. In the foreground is a group of portal leg assemblies, behind a portal rafter assembly, and in the background a number of lattice purlins

the sections are transferred to the various parts of the assembly shop for preliminary operations, such as mitring on power saws, and clipping, piercing and notching on power presses, prior to any assembly. These are standard operations throughout many industries.

The sheeting rails and purlins are manufactured on an assembly line apart from that used for the production of the portal frames. Purlin boom sections are transferred to stillages near the spot-welding assembly line. The open joint tubular bracings are produced on a continuous strut-forming machine in two lengths sufficient for the 20ft length of purlin. The assembly jig for the purlin and sheeting rails (which is illustrated herewith) consists of an aluminium alloy extruded channel cut out to clear the spot-welding electrodes, with aluminium packing plates and location pieces screwed in position. Cam clamps are fitted to retain the section in position in the jig. The jig is mounted on a swivel attachment at each end, this attachment, in turn, is suspended on balancing springs from trollies on an overhead monorail gantry. After assembly in the jig the operators move the jig to predetermined positions across the welding machine. The electrodes pass through the cut-outs and the booms and bracings are spot-welded together. This operation is repeated for the other side of the jig after swivelling the jig over to the other position. The purlin sections are then removed from the jig, transferred to another spot-welding machine for the end plates to be fitted and subsequently inspected and passed to the finishing shop for rust-proofing and painting.

The layout of the assembly line for the portal frame components consists of a buffer stock area for booms and stiffeners ready for fitting together, followed by the spot-welding machines with their long roller conveyors on which assembly of booms and stiffeners is also carried out. Further buffer stock areas hold materials such as finished booms, bracings and gusset plates ready for final assembly in the arc-welding jigs. These areas are followed by the jig assembly lines, welding and subsequent inspection areas.

To fit the stiffeners into the boom sections a simple fixture consisting of several lengths of gravity roller track was placed in a line approximately 3ft high with a timber buffer pad mounted on a steel framework at one end (the steel framework was sufficiently strong to resist any impact load imposed). The main boom sections are then placed on the roller track and the stiffening channels inserted at the other end. The boom and stiffener are pushed sharply along the track towards the buffer, the force of the impact driving the stiffener into position after only four or five blows. The boom section can be passed along the roller track in the opposite direction to the spot-welding machine where each stiffener can first be tack-welded in position, straightened and then completely welded. This process is repeated for each stiffener fitted. In the actual build up of the section it is essential that the stiffener in the base of the boom section is fitted first. These stiffeners are then welded through the base to the boom section. Two rows of spot-welds are sufficient. The stiffeners fitted in the top or centre of the boom sections are spot-welded through the sides of the sections. One row of spot-welds at 2½in pitch, on each side, is considered to be satisfactory.

In cases where the stresses are very severe, such as in the members on the inside of the knee joint, spot-welding of the stiffeners is probably insufficient. If this is so then stiffeners are also arc-welded to the boom section, fillet welds on each side, 3in long being necessary. The booms are now ready for final assembly in the rafter or leg assembly jigs.

The final assembly jigs consist of heavy rolled steel channels welded together to form a shape conforming to the triangulated leg or rafter assemblies of the three-pinned portals. Location blocks, to govern the outer dimensions of the assembly, are welded to the tops of the channels and toggle clamps are screwed in position to retain the members after assembly in the jig. The position of the hinge pin locations is easily ascertained and these location blocks can be welded in position, but the bolt positions for the knee assemblies are not so easily determined. These locations can be approximated by full size templates, but until the first frames have been produced and checked dimensionally they are not finally welded. The jigs are then mounted on fabricated stands 32in high to provide an easy and comfortable working position, and placed in position under the gantries.

The assembly operation follows thus : foot or apex castings are fitted to the boom sections, and after the underside gussets have been positioned in the jigs, they are placed in position with the apex or foot pins and knee locations fixed. The bracings and the upper side gussets are then fitted and the assemblies are then clamped and made ready for arc-welding.

Cold-formed sections are not as stable torsionally as their hot rolled counterparts ; therefore any distortion acquired during the arc-welding of a framed structure, made from cold-formed sections, is almost impossible to remove without damage to some part of the assembly. This means that more attention must be paid to the actual routine of arc-welding. A procedure must be established and every welder trained to carry it out, otherwise excessive distortion due to welding stresses will result.

The arc-welding procedure established for the rafters and legs was as follows : Welder *A* commences welding on the top face of the upper gusset plates of the booms and bracings at the apex. He also welds the upper face of the underside gussets to the bracings and booms ; welder *B* commences the same operation at the knee end ; both welders move from the ends towards the centre of the jig ; as each move is on different sides of the jig they will pass at the centre and move outwards still performing the same operations until complete; the frame is then unclamped, removed from the jig by the lifting blocks on the mono rail and transferred to a flat table and turned over. The arc-welders then perform the same sequence of operations. In the meantime another frame is assembled in the jig. After the first stage of the arc-welding operation the rafter has an edge bow of 2in, but this is pulled out by contraction stresses after the final welding operation has been completed ; the frames are subsequently transferred to the inspection station and are then ready for rust-proofing and painting.

Finishing.—The phosphating plant consists of : (*a*) alkali or trichlorethylene degreasing agent ; (*b*) phosphating tank ; (*c*) water swill ; (*d*) chromate swill ; (*e*) drying stove. Operating details of the plant are as follows : ten minutes' immersion in the alkali degreasing tank at a temperature of 180 deg. Fah., rinse in hot water, immerse in the granodising tank for fifteen minutes, rinse in the chromate swill and finally dry at 220 deg. Fah. After phosphating, the components are ready for painting, which is shown in progress in the last illustration. The members are slung individually on an overhead mono rail, completely immersed in paint and placed on the draining rack for air drying in approximately one and a half hours. The paint used for this particular application was an aluminium, chlorinated rubber primer.

Large Fabricating Plant at Toronto

A NEW plant has recently been added to the Dominion Bridge Company's facilities. The company has maintained for many years a large fabricating plant in Toronto, equipped primarily for structural steel and light plate fabrication, but the new plant is equipped for heavier plate and tank work as well as all kinds of welded structures. The new plant contains about 57,000 square feet of floor space and approximately 150 men can be employed. It marks the first phase of a long-term development and when further units are added, the number of employees is expected eventually to reach an estimated figure of 1500. Existing plate-working and automatic welding equipment has been moved from the present Shaw Street plant and supplemented by various pieces of new equipment. Rolling facilities were augmented by the installation of a pyramid roll, capable of rolling steel plate 1¾in thick by 18ft wide to any diameter down to 33in. Heavy machining is handled by a 9ft by 9ft vertical boring mill. Three new drills have been installed, the largest being a 9ft radial machine. A new burning machine with a capacity of 8ft by 32ft has been installed and plate bending and forming are accomplished by a 12ft by ¾in hydraulic brake of 750 tons capacity. Handling equipment consists of a 25-ton overhead crane in the assembly bay, designed for heavier lifts upon occasion, and an electrified tramrail installation in the preparation bay which can handle a 20-ton load with its four cranes in use. Compressed air is provided by an 1800 c.f.m. compressor.

Extending Range of Diesel Engines

A RANGE of liquid-cooled diesel engines has been announced by J. and H. McLaren, Ltd., Leeds, with maximum outputs of 120 to 240 b.h.p. The new engines are larger than the air-cooled Petter-McLaren P.D. series, described on pages 738 to 739 of our issue of November 26, 1954, but retain the same governed speed of 1800 r.p.m. and, normally aspirated, have a brake mean effective pressure at 12 hour rating of 88 lb instead of 77 lb per square inch. The new L.E. engines, a four and a six cylinder, are particularly suitable for civil engineering plant. Simplicity in design, manufacture and maintenance is claimed to contribute to providing reliable and economical power units.

Each engine has a crankcase and cylinder block cast in iron, extending below the crankshaft which is carried in underslung bearings. The cylinders are formed by centrifugally cast wet liners, seating on rubber rings at the lower end of the water jacket. Doors on one side allow access to main bearings, big-end bearings, camshaft and tappets without disturbing the end covers or the sump. Cylinder heads are cast in pairs, and attached by studs and nuts which are accessible with the rocker gear assembled. One inlet and one exhaust valve are set in line along each cylinder with the injector between them (see Fig. 3) and the rockers are carried on separate shafts for each head. To reach the injector union nuts, the rocker arms can be disengaged from the push-rods and swung into the vertical position. Crankcase ventilation is by small pipes from the rocker boxes into the induction passages. The combustion chamber is formed in the crown of the aluminium-silicon alloy piston which carries three compression rings, the uppermost chrome-plated, and two oil control rings. Bore and stroke are 5⅛in and 6in. Fully-floating gudgeon-pins are journalled in H-section connecting-rods: the big-ends are split at an angle, facing the direction of rotation at top dead centre, so that the rod and piston can be withdrawn through the liner. These and the main bearings have thin wall copper lead split bushes, running on the forged high tensile counterbalanced crankshaft, which in the six-cylinder version carries a viscous damper at the front end. The timing drive is by straight spur gears immediately in front of the flywheel. By removing the hood from the fuel pump drive, the gears can be reached without disturbing the bell housing, while the camshaft itself can be removed through the port covered by the tachometer drive on the front of the engine, the shaft being divided in two so that this is possible in a confined space. A gear pump, chain driven from the crankshaft, delivers oil to an Autoklean strainer of 0·0015in mesh, and provision has been made for dry sump lubrication, effective at large angles of tilt, for contractors' plant. The use of heavy duty oil is recommended. The fuel system is supplied by Bryce Berger Ltd., and includes a mechanical governor. The makers say that the engine is insensitive to fluctuations in fuel quality such as octane number, but it is not intended to run on other than distillate fuels. The power output can be taken by direct coupling or through a friction clutch on an S.A.E. No. 1 bell housing, while a flange-mounted generator is also available; up to one-third of the power can be taken from the front of the crankshaft if required. The engine mountings also are to S.A.E. standards. Unified threads are used throughout, and the electric auxiliaries can be either of British or United States origin. Together with starter and flywheel the engines weigh 2400 lb and 3200 lb.

One application envisaged for this engine is powering rotary compressors of up to 600 cubic feet per minute delivery, and a characteristic of the range for this service is that supercharged versions will be able to give the full compressor

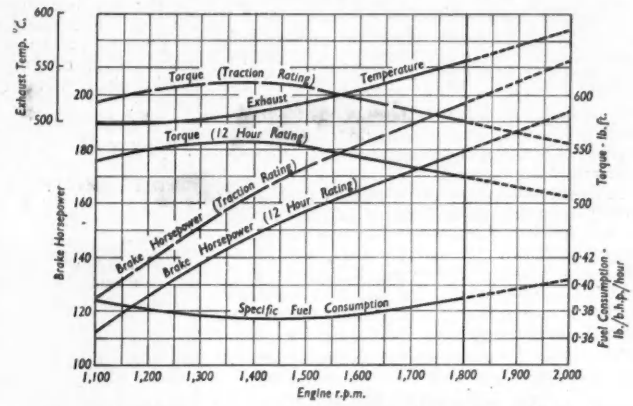


Fig. 4—Variable-speed curves of unblown six-cylinder engine with fixed rack setting. Traction rating 110 per cent load

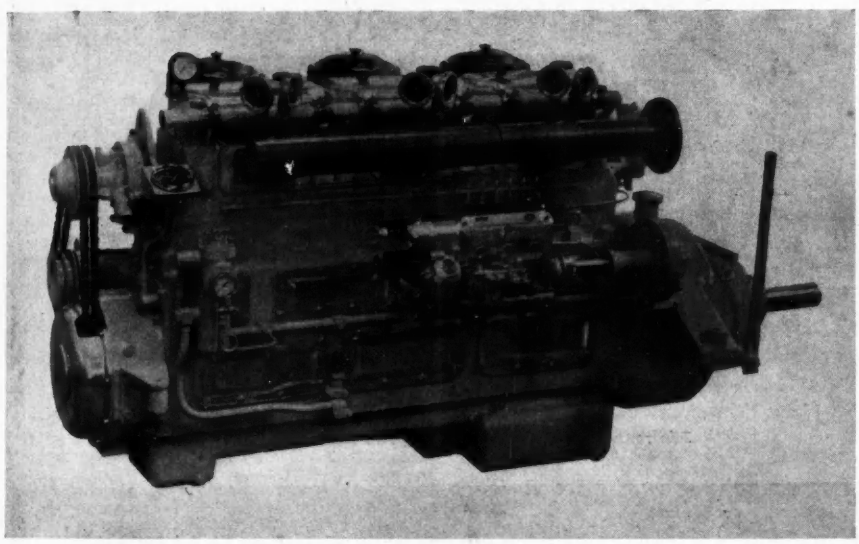


Fig. 1—Normally aspirated six-cylinder engine with power take-off. A thermometer is fitted to each exhaust port

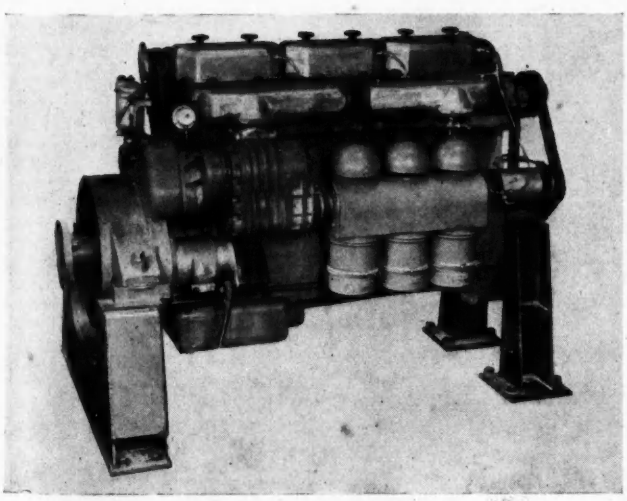


Fig. 2—The supercharged six-cylinder engine, showing the Roots blower and air filters

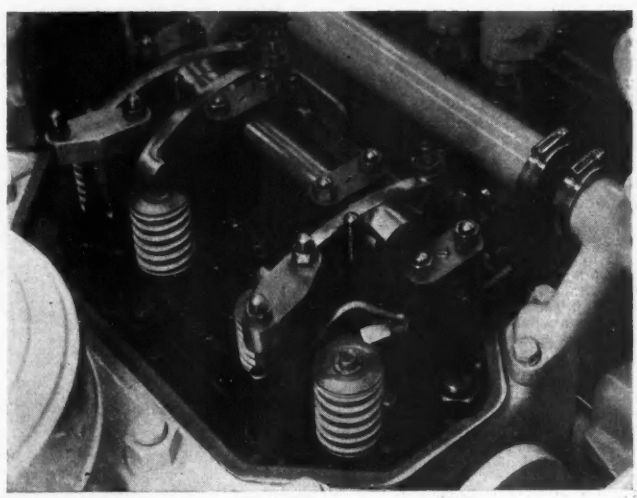


Fig. 3—The rocker arm for the inlet valve of No. 1 cylinder has been swung clear of the valve to give access to the injector unions. A crankcase ventilation pipe can be seen in the foreground

delivery at altitudes of 12,000ft, without entailing any modification to the compressor or chassis. The positive-displacement supercharger, seen in Fig. 2, is arranged to increase output by one-third, and it is anticipated that the specific fuel consumption will be 0·404 instead of 0·375 lb/b.h.p. hour. The system of crankcase ventilation shown may not be perpetuated on production engines. The power-speed relation for 12-hour rating is as follows :

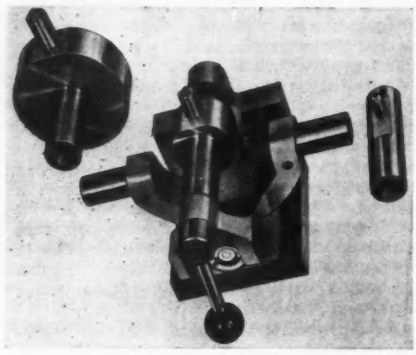
R.p.m.	1000	1200	1500	1800
Four-cylinder unsupercharged (L.E.4)	66	80	100	120
Four-cylinder supercharged (L.E.B.4)	88	106	130	160
Six-cylinder unsupercharged (L.E.6)	100	120	150	180
Six-cylinder supercharged (L.E.B.6)	133	160	200	240

It is anticipated that turbo-supercharged versions will be developed offering up to 50 per cent higher brake mean effective pressures than those of the unblown engines.

A recent visit to the Airedale works enabled us to see these engines and others of the existing range. Among these was an air-cooled P.D.V., as referred to above, fitted with positive-displacement supercharger and driving through a "Torcon" torque converter. The fuel pump was controlled by a governor driven by flexible shafting from the converter output, and the unit was under development for excavators and similar equipments.

Radius Fixture

THE accompanying illustration shows a radius fixture for producing concave radii of ⅛in to 3in on grinding wheels. Made by Engineering Diamonds, Ltd., 26, Warwick Road, Coventry, the "Endia" model "RCC.308" fixture possesses a cast iron base which is bored to take a mandrel holding the diamond. As shown in the illustration, three mandrels are provided to cover the complete range. The



Fixture for forming concave radii of ⅛in to 3in in grinding wheels by means of three interchangeable tool mandrels

fixture can be used either horizontally or vertically on tool and cutter grinding machines, or it can be supported between centres by means of the bar extensions shown. A spirit level in the base permits the diamond tool axis to be aligned with the centre of the grinding wheel to be formed, so that elliptical errors are avoided. Arcs of up to 180 deg. can be produced in wheels of any size, the flange construction of the two larger mandrels ensuring full support for the diamond.

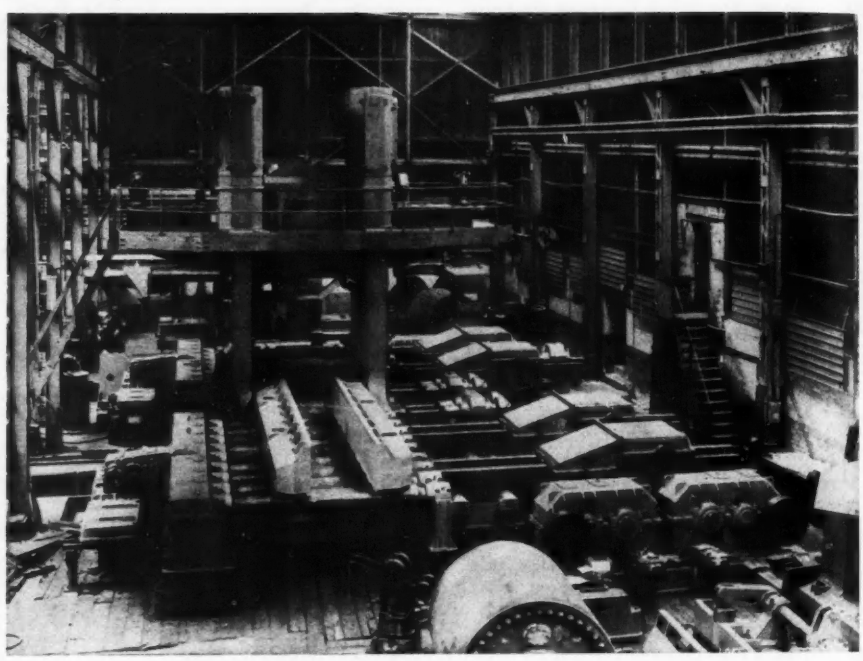
AUTOMATIC CONTROL IN PROCESS INDUSTRIES.—A joint conference of the Institution of Chemical Engineers and the Society of Instrument Technology will be held in the Grand Hall, Caxton Hall, Westminster, London, S.W.1, on Tuesday, October 4th next. The conference will cover a number of aspects of automatic control in relation to the design and operation of process plant and the provisional programme of papers is as follows : "Fundamentals of Automatic Process Control" by R. S. Medlock ; "The Dynamics of Process Plant" by J. McMillan ; "Automatic Process Control and Chemical Engineering" by B. W. Balls and A. H. Isaac ; "Automatic Control in the Steel Industry" by B. O. Smith : "Automatic Control of Batch Processes" by W. A. Goldstein ; "Temperature Control of Large Storage Tanks" by W. A. J. Preece ; "Automatic Control in the Pulp and Paper Industry" by N. C. Underwood ; "The Economics of Process Control" by S. W. J. Wallis ; "The Development of Modern Control Technique and the Pattern of Future Development" by A. J. Young.

34in Blooming and Slabbing Mill

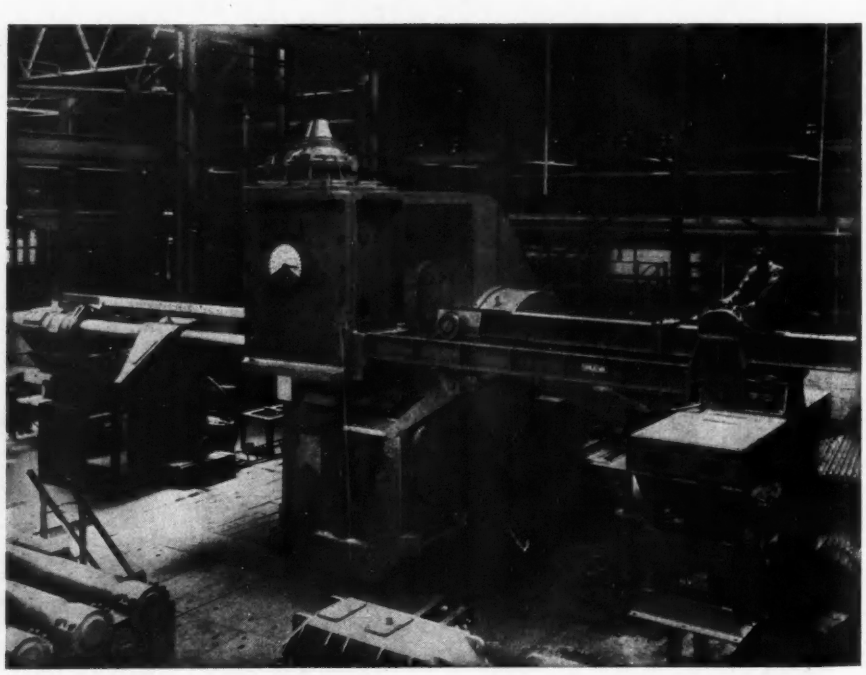
A THIRTY-FOUR inch two-high blooming and slabbing mill is now being shipped to Turkey by the Brightside Foundry and Engineering Company, Ltd., Sheffield. The contract for this mill was placed by the Sumerbank General Directorate, Ankara, for the Karabuk Iron and Steel Works, and the Brightside Company has been responsible for the design and manufacture of all the mechanical section of the plant. The auxiliary electrical equipment is also being supplied from this country.

It is anticipated that the plant will be required to produce 400,000 tons a year. It will therefore work sixteen shifts a week for fifty weeks and will roll ingots of 3 tons, each 20½in mean square, for the production of blooms, or 35in by 12in ingots for the production of slabs. The bloom sizes will be from 12in square maximum to 6in square minimum, and slabs will be rolled up to 30in wide and 5in thick.

The equipment which the Brightside Foundry and Engineering Company, Ltd., has supplied includes the approach, working and run-out tables, the 34in mill and drive with side guard manipulators, an ingot weighing and turning device, a hot cropping and dividing shear with stop and measuring gear, a slab pusher and transfer bed, and the tables and transfer gear for feeding the blooms either direct, or through a wash heating furnace, to an existing 28in structural mill. All the roller tables are group



34in reversing blooming and slabbing mill from the outgoing side



800-ton blade load hot bloom and slab shear, showing stop and measuring gear and crop end pusher

driven through mitre gears and line shafts, and have forged or cast rollers according to the duty or the position in the plant. These table rollers and drives, which are of frame and unit construction, run in roller bearings throughout. On the approach table preceding the 34in mill, there is an overhead weighing device which is fitted with an automatic recorder. The weighing machine is incorporated in the lifting and turning unit which enables the ingot to be presented to the mill either large or small end foremost as required. This unit is controlled from an operating pulpit situated adjacent to it.

The mill train has 36in diameter rolls, 84in long in the barrel, running in fabric bearings, lubricated by water, and driven through universal spindles and a 41½in centres pinion housing from a d.c. reversing motor having a working peak of 14,000 h.p. at 60 r.p.m., and a cut-out peak of 16,100 h.p. at the same speed. The speed of the mill is 0/60/150 r.p.m. The rolls have a minimum lift of 36in and are powered to give a screwing speed of 160in a minute. The top roll is balanced by opposed screws and is fitted with quick release gear to facilitate roll changing. Both rolls can be changed simultaneously and are withdrawn from or entered into the mill by a power-operated sledge. The side guard manipulators are fitted with tilting fingers on the ingoing side. These manipulators are designed to handle all products down to 6in square minimum from the 20½in mean square ingot, and all sizes of slabs produced by the mill ; their traversing speed is 164ft a minute.

The electrically operated hot bloom shear is of the down-adjusting, up-cutting design. It gives a blade load of 800 tons and has a maximum "daylight" between the blades for accepting 12in high blooms and a blade length suitable for slabs 30in wide. The shear is equipped with a crop end pusher for the discharge of the end pieces, and a retractable roller to permit such crops to drop freely into the collecting bins through a chute. The stop and measuring gear is electrically operated for both lifting and traversing and is calibrated to measure blooms from 1·25m minimum to 5·5m maximum. Immediately behind the shear there is a pusher and transfer bed for slabs. The run-out table from the shear is situated so that the blooms can be delivered direct to the 28in structural mill, or side transferred on a skid bed and then charged in a wash heat furnace before being delivered to the structural mill by tables and transfer gear.

The accompanying illustrations are, of course, reproduced from shop-erection photographs. They show the blooming and slabbing mill from the outgoing side, and the hot bloom and slab shear.

Australian Iron and Steel Industry

BY A CORRESPONDENT

Post War Developments

TO keep pace with the rising demand for steel by the metal using industries of Australia, the Broken Hill Proprietary Company, Ltd., and its associate, Australian Iron and Steel, Ltd., have undertaken a major project of expansion, since the war. The general lines of this post-war expansion programme have been briefly described in these columns, and it is now possible to give a comprehensive picture of the new installations at Port Kembla and of the developments which have been proceeding currently for the opening up of new sources of raw material. The first major additions to the plant at Port Kembla—which was chosen as the focal point of expansion of the industry's coke, iron and steel making capacity—were a combination merchant bar, rod and strip mill and a battery of by-product coke ovens, both of which were ready early in 1950. The new merchant mill has a large capacity and produces a wide range of small sections, including ½in to ⅝in rounds, 1½in to 4 9/16in strip and skelp and 0·212in diameter to 0·5in diameter rods. The nominal productive capacity of the mill ranges from 200 tons of five gauge rods to 400 tons of skelp per shift. Together with No. 1 merchant mill, the Kembla Works are now well provided with capacity to roll small sections. With only one battery of by-product coke ovens, comprising seventy-two ovens, the Kembla Works were short of coke making capacity at the end of the war, and in view of the general expansion planned, it was necessary, without delay to proceed with a second battery. By January 1950, forty-eight ovens of the new battery had been completed and were ready to make coke. Between 1950 and 1953, a further twenty-four ovens were added to No. 2 battery, bringing its total strength to seventy-two by January, 1953. Together with No. 1 battery (commissioned in 1938), the Kembla Steel Works are now provided with 144 ovens. Productive capacity is rated at 2940 tons of coke a day, average coking time per oven being 14 hours 13 minutes. While the merchant mill and second battery of coke ovens were under way, work was begun on No. 3 blast furnace, on an eighth open hearth furnace, on the enlarging and strengthening of the bloom mill and on the conversion of the drive of the break-down stand of the continuous billet mill from steam to electricity. Most important of all, work had begun on preparing the site and pouring the foundations of the first units of the wide strip mill, to which much of the developmental work at Port Kembla was of course complementary. In countries like Australia, where large-scale heavy industry is of fairly recent origin and where the population is relatively small, major construction jobs on the scale undertaken by the Australian steel industry during recent years, present serious difficulties of supply ; and the problems of expansion are not made lighter by Australia's great distance from the world's main centres of heavy industry. Largest of all post-war projects, has been the building of the wide strip mill at Port Kembla. A site for the installations which go to make up this project was selected on land owned by the company a short distance to the north of the steel works. The nature of the site was such that many thousands of steel piles had to be driven to support the foundations of the several mills, the machine shop and ancillary buildings. The advantages the site offered were many, not least being the potentialities of the adjacent lagoon for harbour development. Although undeveloped at the present time, the lagoon, which is linked with the sea, lends itself admirably to the creation, by dredging, of a deep water harbour. By the end of 1950 the site was advanced to a stage where it was possible to pour the concrete foundations for some of the main installations, and early in 1951 the project began to take shape above ground. In the meantime, machinery and other equipment required for this, the largest single project to be undertaken by an Australian company—some of it manufactured in the industry's own workshops, some of it by Australian contractors, and some of it imported from the United States and United Kingdom—were being accumulated on the site. Upon completion of the foundation work, progress in the erection of the several buildings and in the installing of the many mills was reasonably rapid, although the continuing shortage of skilled labour during the entire construction period has added materially to the time involved. The rolling of wide steel strip is in itself an integrated process, in which steel slabs up to 10 tons in weight and rolled on the blooming and slabbing mill are reheated before being fed to the hot roughing stands of the wide strip mill. A versatile arrangement was decided on for Port Kembla, whereby slabs rolled down to suitable plate thicknesses could be further finished, if desired, in a plate-finishing section, installed as part of the productive equipment. Alternatively, the rough rolled reduced slabs could be fed, while hot, to the wide six-stand four-high continuous mill, from which they would emerge as steel strip up to 60in wide and of gauges down to 0·048in in thickness. Early in 1954 the hot roughing section of the new installations, together with the plate-finishing section, were sufficiently advanced to be brought into use and beginning in February of that year the mill has been producing plates at the rate of 150,000 tons a year. The plates range in thickness, from ¼in to 4½in, in width from 24in to 75in (sheared size), and in length up to 60ft. When the second half of the plate transfer table is completed in a few months' time, it will be possible to roll plates up to 120ft in length. Production from the plate finishing section has been highly satisfactory since the plant started up in February last year, and it has gone a long way towards fully meeting the Australian demand for plates. The next productive unit to be commissioned will be the six-stand four-high continuous wide strip mill and it is due to start rolling in a few months' time. Whereas sheet-bar is the raw material of Australia's steel sheet manufacturers at the present time, the near future will see its replacement, at least in part, by continuously-rolled coiled strip. Not only will the new product make possible a larger output of sheet ; it should also lead to the turning out of a superior product.

Tinplate Plant.—The final step in the Port Kembla project will be the erection of a tinplate plant with capacity to turn out annually at least 150,000 tons of tinplate. Raw material for this plant will be wide steel strip rolled on the continuous mill and then cold-reduced. At the present time it is proposed to use the hot-dip method for coating the steel sheet with tin to the extent of about 70,000 tons of tinplate a year, but the electrolytic method may also be

This map illustrates the transport problems of the Australian iron and steel industry. Coal is mined close to the steel works at Newcastle and Port Kembla near Sydney. Limestone comes from the neighbourhood of Adelaide and dolomite from the Yorke Peninsula in the same area, and ironstone from Whyalla, not far away, where shipbuilding is also carried on. These places are all some 600 miles by sea from the steel works. A new source of iron ore supply is now being opened up at Yampi Sound on the other side of the continent, some 3000 miles away by sea.

employed at a later date. For many years Australia has stood in need of its own tinplate works, and a stage is fast being arrived at when that gap in her industrial self-sufficiency will be partly filled. The extent of developments at Port Kembla is shown by the capital investment in which it has involved the Broken Hill Proprietary (or B.H.P.) group. The hot strip and plate mill project alone has absorbed over £A30,000,000 ; complementary developments at the steel works nearby have cost another £A10,000,000 or so, and further heavy expenditure must be incurred before the current project is rounded off and the production of tinplate begins. Capital expenditure of the above magnitude dwarfs anything in the previous history of the Australian iron and steel industry. It reflects, in part, of course, the increased costs of plant construction since the war and the erosion of money-values in Australia ; but it also reflects the magnitude of the various projects the steel industry has recently undertaken at Port Kembla. Nevertheless, it is only by embarking upon investment programmes of the above order that the Australian steel industry will keep abreast of the rapidly-growing demand for steel in an industrialised Australia and in step with oversea steel makers, some of whom are competitors with B.H.P. and Australian Iron and Steel, Ltd., for the Australian and neighbouring markets. With pig iron making capacity now approximately 1,100,000 tons a year and ingot steel making capacity 1,300,000 tons, the Port Kembla Works have overtaken and, indeed, surpassed Newcastle—until 1953 the larger producer of the two. Even so, current levels of capacity at Port Kembla in the steel making department are still insufficient to meet the needs of the new rolling mills, some of them already in operation or about to start, and plans are in hand for further increases. Ingot steel making capacity will be added to by the provision of a new open hearth department on a site near the proposed inner harbour, to the north of the existing steel works. Considerable progress has already been made on this new shop, which will comprise initially, two 275-ton basic open hearth furnaces. Combined steel making capacity of the two departments will then be approximately 1,650,000 ingot tons a year. In addition to No. 2 open hearth shop, work is also going forward at the present time on the building of a 3,000,000 cubic foot capacity gasholder for regulating the supply of blast furnace gas, and on the construction of an ironstone beneficiation plant. The latter is required to improve, for smelting purposes, the somewhat friable ironstone now being won on Cockatoo Island, Yampi Sound. Plans are also well in hand for the building of a 5,000,000 cubic foot capacity gasholder for regulating the supply of coke oven gas. The addition of the two gasholders will add materially to the self-sufficiency of the Port Kembla Works, bringing them into line with Newcastle in this important respect. The choosing of sites for the wide strip mill, the No. 2 open hearth shop and the ironstone beneficiation plant, have all been greatly influenced by the State Government's plan to provide Port Kembla and particularly its growing number of heavy industries—steel mills, sheet works, non-ferrous metal manufactures, fertiliser works, to name only the more important—with an inner harbour, to be excavated from the adjacent lagoon. When this much-needed project eventuates, Port Kembla's new iron and steel plants, now completed, nearing completion, at present building, or programmed for in the near future, will all have direct access to shipping. Although the State Government has recently agreed to build a further jetty to ease the congestion in Port Kembla's harbour, its long-term plan to develop an inner basin for shipping carries the ultimate solution to Port Kembla's difficulties. For the steel works, the provision of an inner harbour will mean the achieving of a position which has long been enjoyed by the Newcastle steel works.

Shipping.—With the prospect of opening up a new source of iron ore supply at Yampi Sound on the North-West Coast, B.H.P., soon after the war ended, put in hand a major shipbuilding programme at its Whyalla shipyard in South Australia to cope with the 3000-mile haulage between Yampi Sound and the blast furnaces of the south-east. There is no better indication of the wide range of activities the iron and steel industry must address itself to, once a decision to expand by sizeable amounts its iron and steel making capacity has been made, than the shipbuilding programme of recent years. It is one thing to open new sources of ironstone at far-away places like Yampi ; it is another to transport it to where it can be smelted. Comprehensive planning on many fronts at once becomes necessary. Thus, while work was proceeding at Yampi Sound, keels were being laid down at the industry's shipyard on the other side of the continent. By the time the ironstone quarry was ready to yield in July, 1951, three of the large new ore and general-purpose cargo vessels had been launched from the Whyalla shipyard and commissioned. These were S.S. " Iron Yampi," " Iron Kimberley " and " Iron Derby," each of them of a deadweight tonnage of 12,500 tons and the largest ships yet to be built in Australia. In 1952 they were joined by S.S. " Iron Wyndham," the fourth and final member of the class. The addition of these large vessels to B.H.P.'s fleet has enabled the iron and steel industry to keep pace with the expanding needs of the steel works for much larger quantities of raw material and has facilitated the shipment of finished steel products. From a total of nine vessels when World War II ended (including one chartered vessel), the industry's fleet has been expanded to eighteen at the present time (including five under time charter). Of the eighteen, seven have been built at Whyalla's shipyard—two " Chieftain " class vessels during the war and five since 1945, including the four " Yampi " class and a " Whyalla " class vessel. The latter was launched in 1953 and is the first of a new 10,000 tons deadweight capacity class. Named the " Iron Whyalla," it was commissioned early in 1954. Sister ships will join " Iron Whyalla " in due course. The expansion of the iron and steel industry's fleet since 1945 is perhaps most dramatically expressed in terms of its increased carrying capacity. From approximately 63,000 tons deadweight in 1945, it has risen to 164,000 tons at the present time—an increase of approximately 160 per cent. Geographically, the Australian iron and steel industry, in some important respects, contrasts sharply with the industries of most other producing countries. Most noticeable is its maritime orientation. Without exception, all of its plants and almost all of its sources of raw material are located either at tidewater or very close to it, and its widely scattered centres of operation are knit together almost entirely by sea transport, supplied in part by the industry's own vessels. Similarly, its interstate markets are served by sea, rather than by land transport. Sydney and its hinterland are, of course, notable exceptions, but since Sydney is so close to the two integrated steel plants at Newcastle and Port Kembla (of which it is in effect the geographical hub), it has been found more economical to transport steel overland from the steel works to the nearby consuming industries in the metropolis. For the rest of Australia, however, ocean-going vessels plying between Newcastle, Port Kembla and the main ports of the other States, including raw material producing centres, provide the most economic means of transport. In this respect Australia is unlike most other steel-producing countries. In South Africa, for instance, existing iron and steel plants are far removed from the seaboard, having grown up in response to a very different set of geographical factors ; so, too, have the industries of other countries. In the United States, with its vast and rich interior, the iron and steel industry's geographical centre is many hundreds of miles inland from the Atlantic seaboard, and the world's largest producer has, in fact, very few tidewater iron and steel plants. In only a few countries has the iron and steel industry tended to become concentrated on the coast and, with Japan, Australia is perhaps the most striking example of this small class. The great importance to B.H.P. of its merchant fleet and of the sea lanes which link its raw material sources, its furnaces, mills and its markets therefore needs no stressing.

Development of Raw Material Sources

Ironstone.—For Australia to produce substantially larger tonnages of pig iron (and basic steel), much larger quantities of ironstone have to be quarried and shipped to the centres of production. Ironstone and coal are the industry's life blood, so to speak, and a commensurate stepping-up of their production is the condition precedent for increased steel production. Until 1951, Iron Monarch, 34 miles inland from Whyalla, had furnished all Australia's blast furnaces (six by the middle of 1941), with their needs of ironstone. Discovered in the 1820s and opned by B.H.P. in 1900 (when the company was still a non-ferrous mining and smelting concern), the Iron Knob—Iron Monarch deposits were soon found to contain the largest known reserves of high-grade hematite in Australia. Possession of them had led B.H.P. to erect iron and steel works, and after 1915 they were the source from which the blast furnaces at Newcastle, New South Wales, were fed and of which there were three by the end of 1921. When in August, 1928, a new blast furnace was blown-in at the Port Kembla Works of Australian Iron and Steel, Ltd., further calls were made on the Iron Monarch, which remained until 1951 the only major source of supply for Australia's integrated iron and steel works at Newcastle and Port Kembla. In the course of the fifty-five years it has been worked, the Iron Monarch has supplied upwards of 60,000,000 tons of ironstone to the nation's blast furnaces. In addition to the Iron Monarch (and the deposits which occur in the neighbouring Middleback Ranges), Australia is fortunate in possessing a second relatively large source of ironstone. It occurs on two small islands in the Buccaneer Archipelago, which are part of the territory of Western Australia. The islands are well within the tropics and remote from the settled areas of Australia. They are separated from the mainland by a narrow stretch of water known as Yampi Sound, from which the region takes its name. The two islands (Cockatoo and Koolan), have been known for many years and the leases of the ironstone deposits had been held by a number of groups or syndicates prior to 1928 when Australian Iron and Steel, Ltd., came into possession of the Cockatoo Island leases, it being that company's intention to use the ironstone in its new blast furnace at Port Kembla. When Australian Iron and Steel, Ltd., joined B.H.P. in 1935, it brought the Cockatoo Island leases with it into the group and soon afterwards B.H.P.'s geologists began a systematic examination of the ironstone deposit. It was soon established that in the Yampi ironstone, Australia had another workable deposit, and the company decided that the Cockatoo Island deposit should be opened. Developmental work was under way when the onrush of the Japanese at the end of 1941 compelled the evacuation of the island, and it was not until 1944 that operations could be safely resumed. Since then, more than £A1,000,000 have been spent in opening the deposit on Cockatoo Island and in establishing a settlement. The culminating point came in July, 1951, when the first cargo of Yampi ironstone was loaded into B.H.P.'s S.S. " Iron Yampi," for shipment to the steel works at Port Kembla. A second source of ironstone to feed the industry's growing number of blast furnaces had thus been established and a mechanised quarry, capable of supplying over 1,000,000 tons a year has been brought into production more than 3000 miles by sea from the industrial heart of the nation. On the Iron Monarch the simultaneous working of two benches for ironstone has continued, the latest development being the opening of a new bench, bench " G," to replace the now almost completely worked-out bench " E." The new bench began producing ironstone early in 1954 and together with " F " bench, 100ft above it, is supplying ironstone at the rate of about 2,900,000 tons a year. Preparations are now under way to open up on a mechanised basis the neighbouring ironstone quarries at Iron Baron and Iron Prince. These various developments at the ironstone deposits in South Australia and at Yampi have been and are being planned, to take care of the industry's needs during the next few years. The opening of Yampi has meant that the blast furnaces in New South Wales and South Australia now have an additional source of ironstone and a deposit, moreover, which is reasonably large, high-grade

and accessible, at least to ocean-going vessels. In pioneering the Cockatoo Island project, the iron and steel industry has carried Australia's industrial frontier still further into the unsettled parts of the continent, bringing economic life to places which hitherto have been only names on the map.

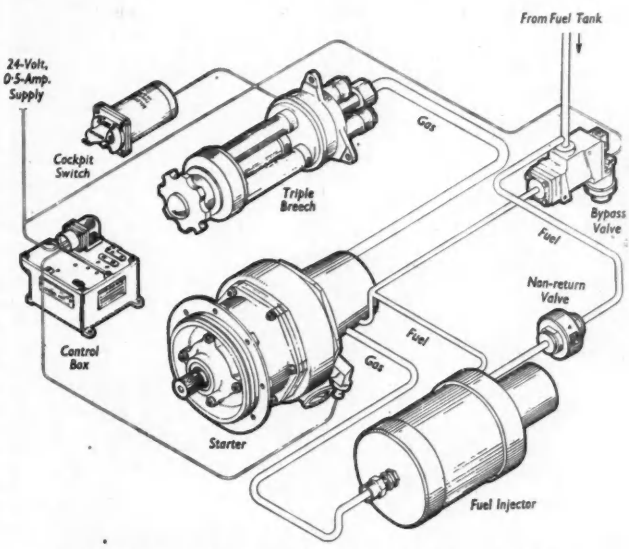
Limestone and Dolomite.—The advantages of having its main sources of raw material on, or close to, the coast, have never been lost sight of by B.H.P. During the last fifteen years, in addition to Yampi, the industry has developed two new sources of raw material—each well located in relation to sea transport. Both are in South Australia—the first, a deposit of limestone well suited for use in blast furnaces and the second, a deposit of high-grade dolomite. After intensive prospecting extending over many years, it was decided to develop a limestone deposit at Rapid Bay, on the eastern shore of St. Vincent's Gulf, about 60 miles south of Adelaide. The deposit was so placed that the limestone could be quarried from a headland, crushed *in situ* and fed by conveyor belt to a storage bin and thence to the mechanised loading jetty. Development of the Rapid Bay project began after the passing by the South Australian Parliament of the B.H.P. Indenture Act in 1937, and considerable progress had been made when war broke out in 1939. Thereafter the project was speeded-up and the first cargo of limestone for the Newcastle Steel Works was lifted early in 1942. The Rapid Bay quarry replaced less satisfactory sources upon which the industry had been accustomed to draw previously. Both the new blast furnace at Whyalla (which came into production in May, 1941), and the furnaces at Newcastle, were soon using flux quarried at Rapid Bay. After the war, steps were taken to improve the industry's source of dolomite—a mineral required in the open hearth departments for refractory purposes. With the expansion of steel making capacity under way, larger quantities of dolomite would be required. A satisfactory deposit at Ardrossan, also in South Australia, on the eastern coast of Yorke Peninsula, was developed. The dolomite occurs very close to the coastline. The size of the deposit was such that it could meet the needs of the industry for many years to come. It remained therefore to open and equip a quarry, to install crushing plant, and to build a mechanised steel-fabricated jetty out into St Vincent's Gulf, at which ships could load the crushed dolomite by means of conveyor belts and boom. The first shipment from Ardrossan was made in 1948 and since then it has replaced the less satisfactory and somewhat scattered sources in the interior of New South Wales, from which the Newcastle and Kembla Steel Works had been accustomed to obtain their requirements. An interesting "by-product" of the company's Ardrossan project is the use on behalf of The Australian Wheat Board of the loading jetty to bulkload wheat grown on Yorke Peninsula. The dolomite jetty is thus of special value to Yorke Peninsula.

Coal.—No basic raw material has received greater attention from the iron and steel industry during its post-war expansion programme than coal. B.H.P. has made great efforts to provide for the industry's growing needs of coking coal, and as a result of the exertion during recent years, a stage has now been reached where coal mined from the company's collieries on the southern and northern fields of New South Wales is coming closer towards meeting the iron and steel works' current needs. Even so, plans are well in hand for further expansions in coal mining capacity, because it is realised throughout the industry that the capacity of the mines must be kept in step with the ever-growing needs of iron and steel plants. Any falling behind in the supply of coal could well jeopardise the vast programmes of capital expenditure, which during the last few years have already raised iron and steel making capacity by 30 per cent. Considerable progress in the mechanising of the company's three collieries on the northern or Newcastle coalfield had been made before 1939, and during recent years the work has been pushed ahead even more rapidly. In addition, a fourth colliery—Stockton Borehole—was acquired in 1949, and it too is being mechanised and modernised. The estimated requirements of the Newcastle Steel Works for coking coal at the present time are approximately 1,600,000 tons a year. So rapid has the expansion of the A.I.S. Kembla Steel Works been, that the industry's southern collieries have had great difficulty in keeping up with it. That they have done so is only because of the vast programme of colliery development B.H.P. has persevered with during the past ten years or so. Originally Australian Iron and Steel, Ltd., at Port Kembla, owned only one colliery on the southern field, namely Wongawilli. After 1935, as part of its plan of expansion for the steel works at Port Kembla, B.H.P. at once set about improving the supply of coking coal and by the time war came in 1939, two more collieries had been acquired in the vicinity of the steel works—Bulli Colliery in 1936 and Mount Keira (now known as Kemira Colliery) in 1937. Both had had long histories and were unmechanised at the time of purchase. Steps were at once take to modernise the three mines, and as a preliminary move coal cutters were introduced. In 1942, a comprehensive modernisation programme was decided on, beginning with the reorganisation of Bulli Colliery. The programme was subsequently extended to Mount Keira and Wongawilli. The ultimate aim of the plant was to equip fully each of these mines with mechanical cutting, loading and ancillary equipment and to provide efficient means of hauling coal from each mine and handling it on the surface. In 1945, the Mount Kembla Colliery, which adjoined Mount Keira on its southern side, was purchased, and the following year a new mine, to which the name Nebo Colliery was given, was opened in coal-bearing land south of Mount Kembla Colliery and adjoining Wongawilli, and has been fully mechanised from the outset. As such, it is Australia's most modern coal mine. All coal mined in the five southern collieries is now mechanically cut and almost all of it is mechanically loaded. The post-war modernisation programme has reached a stage where substantially larger tonnages of coal from the five collieries are being hauled by battery-powered and diesel-electric locomotives out of the mine in 10-ton mine cars, and transported in 60-ton bottom-dumped railway cars, to the steel works. The iron and steel industry has spent more than £A7,000,000 on its southern colliery development programme since the war and the fruits of that expenditure are now being harvested in the shape of the substantially larger tonnages of coal being won.

In the developments of recent years the provision of amenities in keeping with modern standards of welfare and hygiene has not been overlooked, and all the collieries under the control of the iron and steel industry have modern bathing, changing and transport facilities incorporated as essential features of pit-top installations. The needs of the modern-day mine worker, both before he goes on shift and after the day's work is done, are thus provided for adequately. With the expansion of mechanised mining methods and the development of the modern type of colliery, the nature of coal mining has changed. More and more the job involves the miner in the handling of machines rather than the simple tools of mining he was wont to use in the old days. Training for colliery work has therefore become necessary and the steel industry has taken a hand in this important job by setting up colliery training schools at its northern and southern collieries. The northern school has been established at Burwood Colliery and the southern at Nebo Colliery. At both, new recruits are carefully trained in modern mining practice, before they start work underground. In this way a body of skilled operators is being built up and the vastly different needs of the modern coal mine are being provided for. Not only has mechanisation brought with it an increased level of productivity; it has also lessened appreciably the physical burdens of coal mining, reduced the hazards of mining and turned it into an operation where intelligent supervision of machinery has replaced physical prowess with pick and shovel.

Mono-Fuel Turbine for Aircraft Starting

FOR aircraft in which complete independence of ground services is more important than low fly-away weight, or where more than one engine must be started simultaneously, a gas turbine starter running on iso-propyl nitrate has been introduced by British Thomson-Houston, Crown House, Aldwych, W.C.2. Iso-propyl nitrate decomposes under conditions of high temperature and pressure, and these conditions are brought about in the combustion chamber by firing in communication with it a standard Royal Air Force starter cartridge. Enough fuel for one start is contained in the injector, and the pressure of the gas from the combustion chamber moves the piston of the injector against a spring to force fuel into the combustion chamber. The hot gases generated discharge through a turbine, running at about 1100 deg Fah. to accelerate the aircraft engine; the relatively low pressure generated by the cartridge effects the initial engagement of the starter.



System diagram of aircraft starter, the fuel is iso-propyl nitrate

Once the engine has reached the required speed, a centrifugal switch trips the by-pass valve and releases the fuel under pressure in the injector; the spring then refills the injector ready for a fresh start. The electric current required at any stage in the cycle is of the order of 1A, so that the aircraft batteries impose no limitation on the number of successive starts. Iso-propyl nitrate is slightly corrosive both in liquid and gaseous form, and the turbine is made of stainless steel. A contract has been given for the supply of these starters for Armstrong Siddeley Sapphires installed in the Gloster "Javelin."

THE MODEL ENGINEER.—We learn that, as from September 1st, our contemporary *The Model Engineer* is to adopt a new policy. Hitherto it has been a specialised journal for model makers. In future it is to enlarge its content to include articles on mechanical and scientific subjects without, however, sacrificing its interests in model making. *The Model Engineer* during its fifty-seven years of publication has delighted several generations of engineers. The present generation will wish it prosperity in the future in its new guise.

Handling Heavy Machinery with Hydraulic Jack Equipment

IN our issue of July 24, 1953, there was described in some detail the design and use of rerailing equipment for railway vehicles which is made by the German firm Maschinenfabrik Deutschland A-G. of Dortmund. This equipment makes use of special hydraulic jacks supplied by a high-pressure portable pump, carriages, rail platforms, &c., to right and rerail overturned locomotives and other railway vehicles of all sizes and weights. We recently received from the maker's representatives in this country, Feska Industrial Equipments, Ltd., 27, Percy Street, London, W.1, some particulars about other uses to which the equipment has been put where problems were involved in the handling of heavy plant on sites and where the preliminary installation of large cranes would otherwise have been necessary.

In one such application the equipment was used for raising and placing in position on site a large generator casing weighing some 100 tons. This generator was brought to its site by a special railway truck and it had first to be raised to a height of some 30ft and then moved a distance of 35ft into a building where no crane of sufficient capacity was available.

The initial stages in raising the generator can be seen in Fig. 1. With four 60-ton hydraulic jacks it was raised in stages of 1ft, and for this work a supporting frame was built using British Army design pylon equipment. This equipment consists of standard column sections which can be bolted together to form columns or pylons of any required height. At the end of each lifting stage new column sections were introduced in the main supporting structure for the generator and on the adjoining jack support frame, until the machine was elevated to a height of 30ft level with the floor of the turbine room.

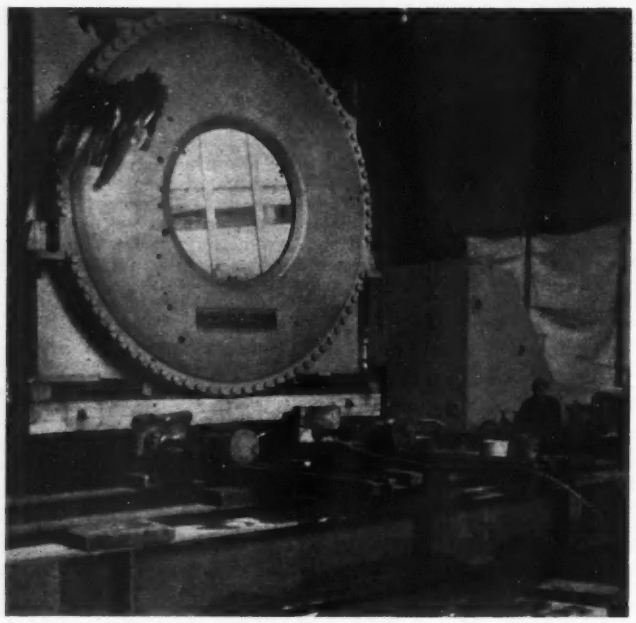


Fig. 1—Raising 100-ton generator casing to a height of 30ft using hydraulic jacks and pylon sections

At that stage it was necessary to move the machine over a distance of 35ft on to its foundations, and for that purpose it was placed on four roller carriages such as are used for moving heavy railway vehicles in the rerailing procedure. These carriages run on double rails fitted with adjustable brackets on to which hydraulic jacks can be set to push in a horizontal direction. The jacks can be seen in operation in Fig. 2, and with them the generator on its carriages was moved along, about 20in between each jack resetting operation, until it was in the required position. The generator was then lifted by means of four long-stroke claw jacks and the carriages and rails removed. The machine was then lowered a distance of nearly 3ft on to its final foundations using the same jack setting.

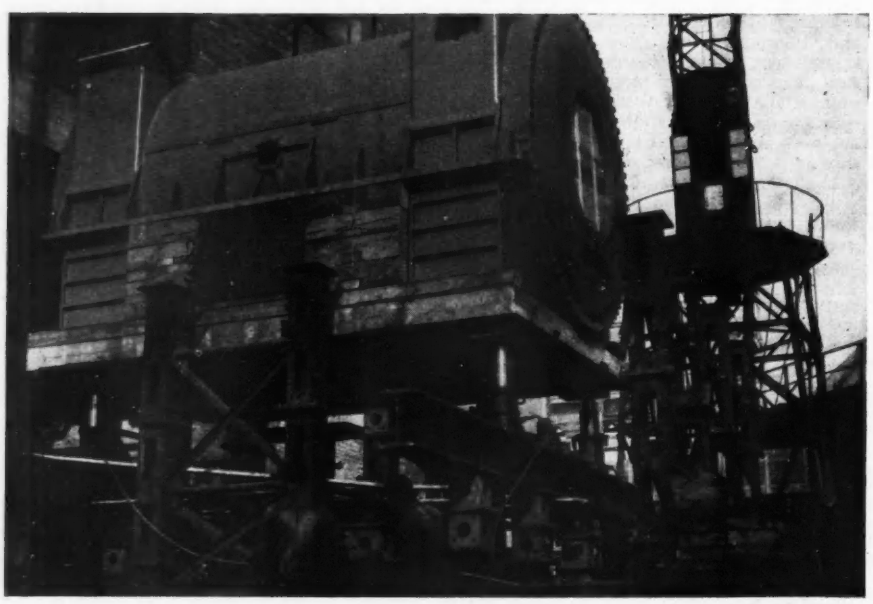
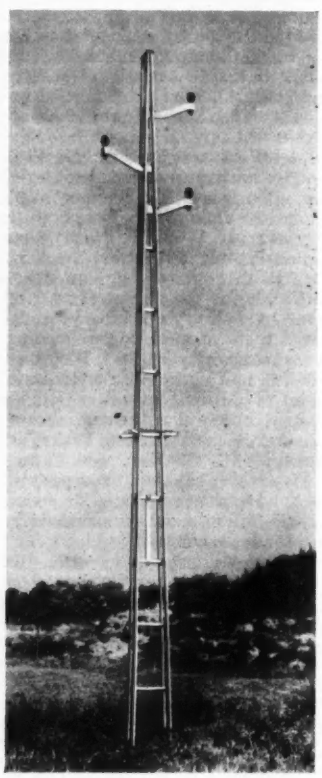


Fig. 2—Moving the carriage-mounted generator casing along floor rails by means of hydraulic jacks

Tubular Pole for Overhead Transmission Line

A LIGHT braced pole for distribution and transmission lines has been developed jointly by Painter Brothers, Ltd., and British Insulated Callender's Construction Company, Ltd. As may be seen from the accompanying illustration, the pole is fabricated from steel tubing. Four steel tubes of 1in nominal bore by 12G to class "A"—B.S. 1387 are used for each pole. The tubes forming each longitudinal face are connected at intervals by batten plates welded to the tubes, and to these battens are bolted spacers, made from rolled steel flats to form "I" sections, which connect the two longitudinal frames together, on site, to make the complete pole. The two longitudinal faces are fastened together at the top by a locking unit and a cap plate which are connected by a through bolt or insulator spindle. The cap plate also serves to seal the ends of the tubes from the atmosphere. All the structural parts are hot dip galvanised, bolts being hot dip spun galvanised. The tubes are left open during the galvanising and are therefore protected both inside and outside.



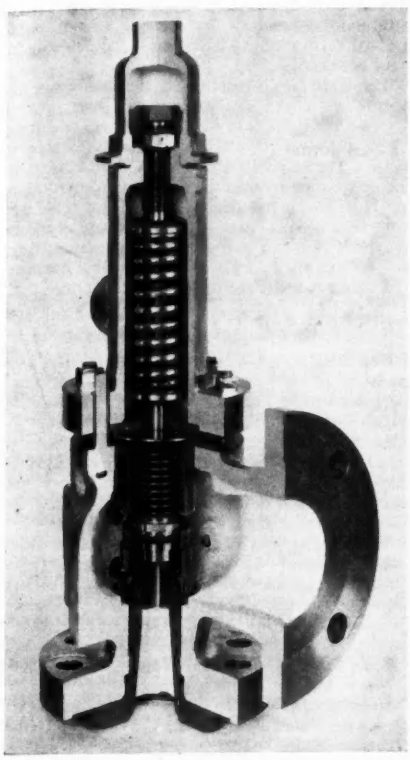
A clearance of 25ft or 30ft above ground is given by this tubular transmission line pole. It will support an ultimate head load of 1250 lb

The pole has been designed for an ultimate load of 1250 lb at the pole top and has been comprehensively tested, it is claimed, so that poles are of a guaranteed known strength.

The pole is made in two sizes, with overall lengths of 30ft and 35ft. No concrete base is needed, and the bottom 5ft of the shorter pole, or 5ft 6in in the case of the longer one, is buried below ground level. This buried part forms a reverse "A" below the exposed part. The 30ft pole weighs 251 lb and the 35ft one 288 lb; the three high-voltage cross arms shown in the illustration each weigh 14 lb in addition to the pole's own weight. This design cannot be used for "angle" or terminal positions, but a similar, more substantial, design may be substituted in such cases.

Balanced Relief Valve

IT is frequently desirable that a relief valve should be balanced against varying back pressures, both to obtain a consistent response and also to avoid unstable operation. This can be achieved by sealing the interior of the valve with a steel bellows having the same effective area as the nozzle and disc seat, but the turbulence caused by choking flow past the valve is highly damaging to such a bellows.



A sectioned valve showing the stainless steel bellow surrounded by its shield

Crosby Valve and Engineering Co., Ltd., Ealing Road, Wembley, Middlesex, claims that the new "Protecto"-seal valve does not suffer in this way because the bellows is enclosed in an open ended shield, and, when the valve lifts, the top of the disc closes off the shield and completely protects the bellows from excited vibration. The major components of this valve, which is illustrated herewith, are interchangeable with those of the existing range of the firm's products.

Infinitely Variable Gear

LARGE capacity, low wear and mechanical efficiencies of 85 to 92 per cent are claimed for the Schaerer-Beier variable speed gear, now made in this country under licence by Armstrong Whitworth (Metal Industries), Ltd., Gateshead, 8, Co. Durham. The accompanying drawing shows one form of this equipment, which, in addition to the infinitely variable gear, comprises reduction gearing and clutch.

With regard to the principle upon which the Beier gear is based, i.e. variable-ratio friction discs, it is stated that large capacity is achieved by subdividing the transmitted torque among a large number of discs, which, individually, can therefore be very lightly loaded, in spite of the fact that the coefficient of friction is low owing to the necessary lubrication.

Referring to the drawing, the belt-driven input shaft *A* has a splined section on which are mounted a number of double-conical discs *B*, compressed axially by the helical springs *C*. The flanks of these discs engage with the raised edges of another series of discs *D*, mounted on three splined shafts *E*. By altering the distance between shafts *A* and *E* the effective radius of contact in *B* can be adjusted to obtain the required gear ratio. This is achieved by swinging the arms *F* in which the shafts *E* are mounted about a fulcrum *K* fixed relative to the housing. The other end of each arm is attached through a link *G* to a ring *H* which can be turned by means of the screw spindle *I* and the handwheel *J*. On the pins *K* are mounted the gear wheels *L*, which engage with their respective pinions fixed to shafts *E*, and transmit the rotation to the external gear *N* and the internal gear *O*. Both *N* and *O* are mounted in ball bearings, first *O* on *N* and then *N* itself on the end of the output shaft *P*, to which either can be locked with the clutch *Q*, which thus provides two speed ranges as well as a neutral position.

A number of variants of this gear are built to suit particular applications. It is, for instance, possible to interchange the conical and rimmed friction wheels, or to invert the drive, making the driving end the output end and conversely.

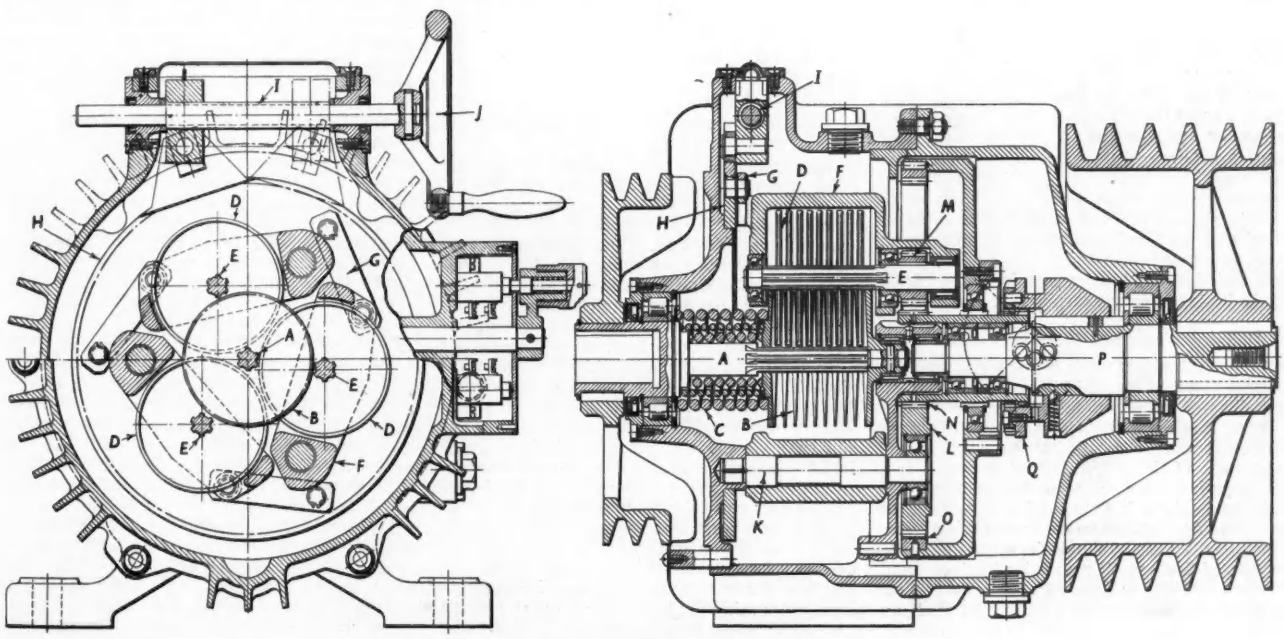
It is clear that the friction wheels undergo axial movement as they are pushed in and out of mesh. Jamming by tilting is avoided by the symmetrical arrangement of the three (sometimes six) shafts *E*, and by slightly bell-mouthing the splined bores.

One property of the design is a tendency to reduce speed as output torque increases. This may be explained by noting from the diagram that as the load torque increases gears *L* are retarded, with the result that the pinions *M*, by rolling over gears *L* as over a rack, tend to swing the arms *F* to the low-speed position. When this would be undesirable, it can be prevented by holding the ring *H* to its setting, as is the case here. It is stated that frictional force is entirely due to the oil film drag between the discs and that no metallic contact takes place. Under these circumstances, the amount of mechanical wear is claimed to be exceedingly small, and can be reduced still further by an arrangement which, by means of a screw, tightens the springs *C* only to the extent required to transmit the actual torque applied. Sudden overloading will simply lead to slipping of the friction wheels without causing any damage, it having been found that the gear is able to withstand a 25 per cent slip for several minutes without ill-effects. The principle of the gear is said to be equally applicable to small and large units up to several hundred horsepower.

Wheel Washing Plant

EQUIPMENT for removing dirt and grit from the driving wheels of lorries operating at quarries or construction sites is being manufactured by William Moseley (Engineers), Ltd., of Feltham, Middlesex. Use of this washing plant enables vehicles to comply with local by-laws which state that no mud or dirt must be deposited on public roads. The washer consists of a heavy steel grid in the centre of which are two free-running rollers spaced to allow maximum contact with the rear wheels of the average four-wheeled lorry. When not in use the rollers can be locked by a hand brake. Connected to this brake is the supply valve to a series of nozzles. After the vehicle has been driven on to the rollers, the brake is released and the water spray turned on. The wheels are then rotated in top gear, which causes the mud and grit to be flung clear, the water completing the rinsing process.

SERVICE RESERVOIR FOR SOUTHEND WATERWORKS.—A new service reservoir of 5 m.g. capacity was brought into operation at Oakwood, Daws Heath, recently by the Southend Waterworks Company. It cost £88,000 to construct; building started in April, 1954, and was carried out by Shellabear, Price, Contractors, Ltd. In conjunction with the existing Oakwood reservoir, of 3¾ m.g. capacity, which is over fifty years old, it will act as a balancing reservoir at the end of the 14-mile long 28in diameter pumping main from the company's river supply at Langford. The depth of water at a T.W.L. of 220ft A.O.D. is 15ft.



Infinitely variable gear employing variable-ratio friction discs

Industrial and Labour Notes

Engineering Wages, Hours and Holidays

At the annual conference of the Confederation of Shipbuilding and Engineering Unions, which was held at Blackpool last week, resolutions were passed instructing the executive to put forward claims for increased wages, a forty-hour week, and for three weeks' paid holiday. There was also another discussion on the Confederation's *Plan for Engineering*, a plan which urges the nationalisation of sections of the engineering industry. A resolution on this last subject welcomed the reopening of talks between the general council of the Trades Union Congress and representatives of the Confederation on the proposals set out in the plan.

The conference agenda contained eight resolutions on wages, six of them relating to the wages of adult workers and the other two to the wages of apprentices, boys and youths. The composite resolution put to the conference appears to have been very much on the lines of a motion submitted by the Amalgamated Engineering Union, which asked that negotiations be opened with the Engineering and Allied Employers' National Federation and with the Shipbuilding Employers' Federation for a "substantial increase in wages." In proposing the resolution, Mr. R. Openshaw, president of the A.E.U., mentioned that there was complaint that these claims were an annual affair, but, he said, nobody objected to an annual increase in profits. He added that although warnings about the disastrous effect of conceding these wage claims had been expressed, employers had continued to prosper. From that, Mr. Openshaw argued that wage advances might well have assisted the prosperity of engineering employers by compelling them to modernise and to improve their efficiency. No specific amount for the wage increase was mentioned in the resolution; the details, it has been suggested, were likely to be decided at a meeting of the Confederation's executive arranged for yesterday (Thursday).

The resolution directed towards obtaining a shorter working week included a demand for a reduction of overtime working. It was emphasised at the conference that the Confederation's aim was to obtain a forty-hour week in the engineering and shipbuilding industries "without reduction of pay." This resolution was moved by a representative of the Amalgamated Engineering Union, who claimed that American engineering workers produced more than British in less time. It was stated also that some progressive British firms had already introduced a forty-hour week, and that the stage had already been reached in automation when hours must be reduced. About "constant and excessive overtime," it was submitted by a representative of the Electrical Trades Union that it injured the health of the workers, interfered with their leisure, undermined their unions' activities, and encouraged employers to quote high figures of average earnings when increases in basic wages were being sought. The resolution on holidays asked that the Confederation's executive should press for three weeks' paid holiday instead of two, and that holiday pay should be calculated on the basis of average earnings.

Railway Wages and Working Conditions

At the end of last week it was stated that the executive of the National Union of Railwaymen had directed its negotiating committee to give "urgent consideration" to the framing of a wage claim. It will be recalled that at the annual conference of the N.U.R. about a month ago, the executive was directed to formulate a wage claim and submit it for negotiation as soon as possible. At the conference it was decided that, if possible, the claim should be agreed with the Associated Society of Locomotive Engineers and Firemen and the Transport Salaried Staffs' Association. Failing the reaching of such an agreement, however, the N.U.R. conference directed its executive to pursue the claim alone.

Meanwhile, the Associated Society of Locomotive Engineers and Firemen has submitted to the British Transport Commission a claim for improved working conditions for its members. The four points in the Society's claim are: payment of wages to men absent from duty because of sickness or accidents; the full implementation of the forty-four-hour week; the elimination of anomalies in mileage working, and an extension of the period during which night duty rates are payable. It is understood that the point about the forty-four-hour week envisages the abolition of rest-day working. At present, locomotive men work eleven days, totalling eighty-eight hours, in a fortnight. This period makes provision for two Sundays off and one other rest day. On account of manpower shortage, however, local agreements have been made at some centres under which men work, at higher rates of pay, on their rest days.

Overseas Trade

The Board of Trade says that the recorded figures for the United Kingdom's balance of visible trade continued to be considerably affected in July by the railway and dock strikes which occurred in the preceding month. The recorded value of July exports was £223,100,000, which was £66,100,000 above the June figure, but 4 per cent below the average monthly rate of export in the first half of this year. On the other hand, imports in July were recorded at £338,800,000, which was £44,800,000 more than in June and 7 per cent above the monthly average over the first half year. The value of re-exports in July was £7,900,000, or 16 per cent below the monthly average for the first half year. The recorded excess of imports over exports and re-exports was thus £107,800,000 at the end of July, compared with a monthly average of £75,600,000 in the first half of the year.

The Board of Trade has explained, however, that these figures do not give any clear indication of the trends of the United Kingdom's trade, because it will probably be some time before the direct effects of the transport strikes cease to show in the monthly report. From an examination of the way in which the dock strike has influenced the figures, it would appear that the export figures for June and July have been affected more than those for imports. It is stated that the reasons are partly statistical and partly concerned with the handling of cargoes. Although the dock strike ended on July 3rd, it seems that the flow of export documents did not return to normal until after the middle of the month. Moreover, conditions at the docks during the strike favoured the clearance of imports rather than exports.

Iron and Steel

The Iron and Steel Board has reported that steel production during July averaged 307,700 tons a week and was thus at an annual output rate of 16,002,000 tons, compared with 13,682,000 tons in July last year. The effect of annual holidays is, of course, reflected in the July figures. Pig iron production in July averaged 230,800 tons a week, representing an annual rate of 12,000,000 tons, compared with a rate of 10,984,000 tons in July, 1954.

In the latest issue of its *Monthly Statistical Bulletin*, the British Iron and Steel Federation has included an informative survey of the steel industry on the North-East Coast. It points out that the Cleveland iron ore beds are now largely depleted, and that there is some concern over the long-term supply prospects for better quality Durham coking coals. Nevertheless, the *Bulletin* says, the area continues to hold its position as one of Britain's main iron and steel centres. Last year, the N.E. Coast led all ten districts of this country in the production of pig iron, accounting for just under a quarter of the United Kingdom's total output; it was second in crude steel production, with one-fifth of the national total, and was the main producing area of heavy rolled products. In the five-year period 1953-1958, over £60,000,000 is to be spent on capital developments in the area, extending the production capacity by nearly two-fifths to 3,650,000 tons of pig iron and 4,750,000 tons of steel annually.

The *Bulletin* comments on the decline in the output of Cleveland ore. Last year, output totalled only 871,000 tons, compared with over 2,000,000 tons in 1937 and 6,000,000 tons in 1913. This decline has meant that almost all the post-war increase in pig iron production on the N.E. Coast has been based on imported ore. Last year, the amount of imported ore used was nearly 80 per cent above 1946 and accounted for 83 per cent of the ore consumed in blast-furnaces and sinter plants in terms of iron content.

Competition in Export Markets

The British Engineers' Association has prepared a survey of exports of machinery and electrical apparatus in the years 1950-1954, which shows the extent of these exports from the principal exporting countries to all markets of significance. Among the figures included in this survey are the values of machinery and electrical exports for the year 1954 from the following countries, the figures in parenthesis indicating last year's totals as percentages of the 1953 figures:—U.S.A., £918,200,000 (96); United Kingdom, £577,900,000 (101); Western Germany, £506,500,000 (114); France, £136,600,000 (103); Switzerland, £111,100,000 (106); Netherlands, £83,600,000 (122); Sweden, £68,300,000 (109); and Japan, £44,600,000 (174).

In some explanatory notes on the figures, the survey says that in 1953, for the first time since the war, many countries, including the United Kingdom, failed to increase the value of their engineering exports. Last year, however, in the case of most countries, engineering exports were higher in value than in 1953. But the increase in exports from the United Kingdom was modest, the total value being below what it was in 1952. On the other hand, the survey continues, the U.S.A. exported less last year than in 1953, and for the U.S.A. engineering industry it was the first time since the war that the annual export figures had not increased.

The survey directs attention to the increase of engineering exports from Western Germany. It observes that if engineering exports from the United Kingdom and Western Germany continue this year to move as they have done in the recent past, it may be that in 1955 the lead which the United Kingdom has had since the end of the war will be further diminished. As an indication of the directions in which German sales effort is expended, the survey lists markets in which in 1954, as compared with 1953, exports from the United Kingdom decreased and exports from Western Germany increased. For the United Kingdom, it is observed, those countries represented a reduction of about £26,000,000, and for Western Germany an increase of about £37,000,000.

Coal Output and Stocks

Last week, coal production increased to 3,574,600 tons, following the drop over the August Bank Holiday. Production of deep-mined coal, however, continues to be influenced by annual holidays. It is estimated that, last week, recognised holidays caused a loss of 840,000 tons, and that disputes caused a loss of 27,100 tons. In the first thirty-two weeks of this year, ended last Saturday, coal production totalled 132,756,800 tons, or 3,500,000 tons or so less than in the comparable period of last year. Coal imports amounted to 6,905,200 tons, and on August 6th distributed stocks totalled 14,047,000 tons, compared with 14,787,000 tons a year earlier.

Annacis Industrial Estate, British Columbia

BY OUR CANADIAN CORRESPONDENT

ANNACIS ISLAND is situated near the forest product, manufacturing and shipping centre of New Westminster, and is the first of the small islands of the Fraser Delta in British Columbia. As many readers of THE ENGINEER will know, the island was selected, for industrial development by the Grosvenor Estates, on the late Duke of Westminster's initiative. Industrialists will be able to lease factories or sites laid out according to their particular requirements on the island. This leasehold arrangement is, we understand, a novel development in the industry of Western Canada. Development was undertaken in conjunction with John Laing and Sons, Ltd. That firm has established a Canadian subsidiary and has carried out the actual work on the island. Annacis Island is about 2½ miles long and a mile wide at its mid-section ; it was, until recently, a moderately fertile farm area, with considerable sections of underbrush, swamp and woodland. It lies adjacent to the largest of the Fraser Delta islands, Lulu Island, which contains a variety of mills and other manufacturing plants, and is itself a very rich area of agricultural production. This latter island is connected to New Westminster by a rail and highway bridge, and is now joined to Annacis Island by a causeway which will carry the rail and road traffic to the industrial area. This causeway, which was inaugurated in July of this year, is a rock and earth fill structure.

Major developments in the site area were naturally delayed until completion of this causeway, due to the necessity, previously, of having to take all equipment and material to the island by tender and barge. Preparation work was commenced, by the contractor, late last summer, heavy earth-moving equipment arriving from the United Kingdom on July 3, 1954. After a careful survey of the whole island it was considered that one section at a time should be completed, and, radiating out from the administration area, at the north-west corner of the island, road, rail and drainage facilities, coupled with the necessary utilities, would be extended as the building requirements and surface cover progressed. The first stage of the work is now complete, the administration building has been erected, and there is a network of roads and services ready to serve the industrial plants as they are built, over an area of about 200 acres.

Because of the unevenness of the existing surface, it was decided that it would be necessary to raise the level of some areas of the island by approximately 5ft, and to do so sand and river material was pumped on to the island from the river bed. A dredge, positioned off the south-west end of the island, and worked westward, pumping the dredged material on to the island surface, upon which drainage systems had been laid, and the excess water from the pumped silt and sand drained off into the river. This alluvial deposit will be suitable for both heavy and medium industries, with one and two-storey structures, on slab foundation. The total quantity of fill needed will be about 12,000,000 cubic yards, 1,500,000 cubic yards having been placed by last month.

The present layout of the site is cut by a drainage canal which has been connected by corrugated conduit to the three storm water pumps, which discharge over a spillway into the Fraser. The dyking, which formerly surrounded the island, has now been backed to its crest with the surface fill, and this has permitted the outlet drainage to pass directly into the river at low tide, and at high tide there is a drainage storage, in the ditch and storage terraces, to permit the storage of even a very heavy run-off, until the tide conditions again permit maximum outlet into the river, or until the storm water pumps take over, automatically.

This storm water storage and pumping system is composed of a large concrete-floored storage ditch crossing the island at the mid-point of the first stage. The ground, terraced down to the main storage ditch will be planted, but, in the event of a prolonged storm, or exceptionally high river level, an additional storage will be afforded by this terrace area. At the southern end of the storage canal, a 48in asbestos-coated, corrugated culvert connects the storage canal to the storm pumping station well, where the water passes through the trash racks into the pumping chambers.

Under normal conditions of low water, the discharge from the canal by-passes the pump station and is discharged directly into the river ; at high water, the back pressure closes the check clapper of the discharge pipe, and the water backs up into the storage canal. It is only in the event of extreme and prolonged high-water level, as in the high spring tides, that the pumps take over.

The foul sewage system is again a case of normal drainage at low water, and pumping at high levels. For this purpose, caissons of tunnel liner corrugated steel well curbings were sunk at three discharge points, and then walled with reinforced concrete. Because the lower part of the excavation took place in water-bearing sand, the original ground surface being only to a depth of 4ft to 5ft at the well sites, well pointing was found to be necessary ; the excavation being carried down to the —4ft level. In these sewage wells, pumping floors were constructed about halfway down, and on these platforms, with central ports for the vertical suction pipes, the discharging pumps were installed, each well, or ejector station, holding two pumps below ground level. Beneath the platform the sewage collection sump is located, to the bottom of which the suction pipes extend. At the present time no sewage treatment is required, and discharge is made directly into the river. Three ejector stations have been provided in the first stage of operations, one being located to serve the administration area, and the other two are grouped to serve the industrial " compound." Further ejector stations will be added as the need arises. A standby power plant is installed above ground, near each ejector station and in the event of power failure a petrol-driven generator set can switch in.

Water is supplied from the Greater Vancouver Water District, the service mains already having been laid along many of the roads now constructed. Every effort has been made to keep the utilities from under the road surfaces, and storm sewers, electric, water and telephone services have been laid below ground, outside the kerb area. Natural gas piping will also be laid. There is, at present, a road and rail connection over the causeway and to the factory areas, where loading spurs will run to each plant.

When further developments are made, ocean-going freighters will be able to load and unload at deep-water berths on the island. The long-term programme takes into account up to about twenty-five years of growth. The island's 1260 acres, it is estimated, will be, by that time, largely industrialised.

Continental Engineering News

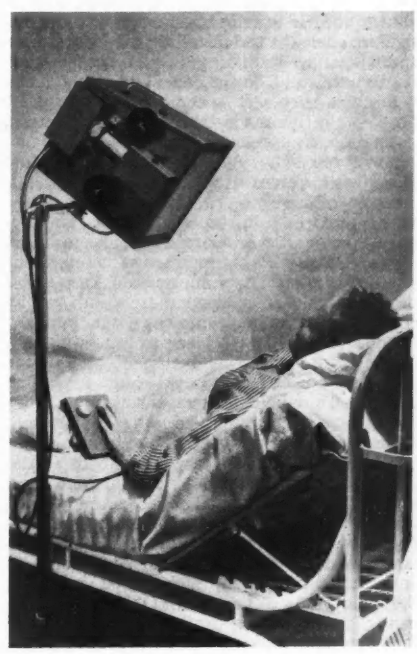
Hanover Machine Tool Exhibition

In accordance with previous announcements, the Machine Tool Exhibition, Hanover, 1955, will take place from September 11th to 20th at the Exhibition Grounds, Hanover. Over 500 manufacturers of machine tools, precision instruments and accessories for machine tools, are scheduled to take part, including some forty firms from abroad. As on former occasions, the exhibition will be divided into groups housed in separate halls as follows :—(1) Planing, shaping, slotting and broaching machines; lathes, turret lathes and automatic lathes ; gear cutting machines. (2) Lathes, including turret and automatic lathes. (3) Drilling and boring machines, boring and milling units. (4) Milling, sawing and filing machines. (5) Presses, die casting machines, and welding equipment. (6) Non-cutting machinery. (7) Precision tools and measuring instruments, testing machines and apparatus, electric tools, tool grinders ; electrical, hydraulic and pneumatic accessories.

Within the framework of the exhibition there will be a special show entitled " Iron and Steel in Machine Manufacture." This will be held in the open air and in the pavilions, and the new hall of the iron and steel industry. Information regarding the exhibition can be obtained from the organiser, Verein Deutscher Werkzeugmaschinenfabriken (V.D.W.), Frankfurt/Main, AM Hauptbahnhof 6, or from the agent for the United Kingdom, Schenkers, Ltd., 27, Chancery Lane, London, W.C.2.

Reading Aid for Disabled Patients

For the benefit of patients whose condition makes it difficult or impossible to hold a book, Centrala Filmarkivet A/B, Stockholm Va, Hudiksvallgatan 8, has produced a microfilm reader with a push-button control which responds to the slightest touch. Our illustration



16mm microfilm reader on adjustable stand. The press-button control operates at the slightest touch

shows this apparatus, which is called the " Bioscope." Operated at 12V through a mains transformer, it runs a standard 50W car bulb which gives an image on the screen bright enough not to require a darkened room. The company supplies books and other material on 16mm unperforated film, at a cost which, it is stated, sometimes is below that of the printed copy. It may be seen from the illustration that the unit is mounted on a stand, an arrangement which permits height and angle to be easily adjusted. The magnification is also adjustable to suit patients whose eyesight may be weak. Specially large screens are supplied for the reading of magazines and other matter above average size.

Documentation of Process Control

In view of the steadily increasing importance to industry of instrumentation, the Committee for Instrumentation and Process Control of the Verein Deutsche Ingenieure has set up a working group under Dr.-Ing Otto Frank, Frankfurt/M, to deal with documentation. As a beginning, this group is publishing every month in the journal *Regelungstechnik* brief classified abstracts of some fifty articles on the subject. The journal is published by Verlag R. Oldenburg, Munich. For the purpose of distribution within a firm and for making card indexes, the publishers will supply on request special reprints printed on one side of the paper only.

Babcock and Wilcox Research Centre at Alliance, Ohio

No. I

Most of the research and development work conducted by the Babcock and Wilcox Company in the fields of thermodynamics, metallurgy, ceramics, physics and chemistry has now been concentrated in a research centre at Alliance, Ohio. Having started with one building in 1947, the centre to-day comprises eleven buildings and employs a staff of 350. This article describes the establishment and reviews certain major developments, particularly in the fields of super-critical boilers, fuel burning, metallurgy, refractories and atomic energy.

THE research centre of the Babcock and Wilcox Company, at Alliance, Ohio, which is shown in the accompanying aerial view, has modern chemical and metallurgical laboratories, special testing facilities, pilot plants, experimental furnaces and boilers, an alloy foundry and a machine shop. It is equipped to investigate problems in fuels and their combustion, steam generation, heat transfer, and metallurgical and ceramic research to develop high-temperature alloys and refractories. It approaches this complex of problems via the avenues indicated by its three basic divisions : product development, materials development and technical service. These divisions, whether acting alone or as sources of mutual information, keep ahead of the steadily advancing needs of industry by conducting continuing investigations into the factors limiting the efficiency of heat utilisation of fuels, of engineering materials, and of the same materials incorporated into functional designs. Thus, investigations of boiler operations at super-critical pressures led to the development of the company's universal pressure unit, a major contribution to one of the basic trends in the steam-generating field to-day : the drive toward the realisation of the larger economies which exist in the realm of higher pressures and temperatures. Babcock and Wilcox is building a new high-pressure unit for the American Gas and Electric Company, which will be situated at the Philo power station of the Ohio Power Company ; it will have a capacity of 675,000 lb of steam per hour and will operate at 1150 deg. Fah. and at the super-critical pressure of 4500 lb per square inch.

The important part played by the research centre in the development of efficient methods for firing pulverised coal and in the design of the cyclone furnace which has revolutionised the burning of coal during the past decade, reflects a second important trend underlying much of the work at Alliance and in the field as a whole. Because more and more power stations are being forced to burn low-grade solid fuels, the need for increasing the efficiency of their utilisation becomes increasingly acute. Studies made on coals from all over the world, and on such fuels as petroleum coke, which may soon remove residual oil from the American market, have resulted in laboratory methods by means of which important commercial-scale burning characteristics of any solid fuel can be predicted. Research on the combustion of all types of fuel (coal, oil, gas, waste materials, nuclear energy) is a major part of the company's research activities. One of its important results is a newly developed oil-burning cyclone furnace.

Still another result of research at Alliance is the development of a high-pressure water tube boiler for use in a coal-burning locomotive. The boiler operates at 600 lb per square inch and 900 deg. Fah., giving it high thermal efficiency. The first such Baldwin-Westinghouse locomotive, which combines the Babcock and Wilcox high-pressure boiler with a Westinghouse steam turbine and electric drive, is rated at 4500 h.p. It operates at double the efficiency of the average coal-burning reciprocating steam locomotive, and can compete favourably with diesel-electric locomotives in industrial areas where cheap coal is abundant. After trials at Alliance, the boiler is being tested further by the Norfok and Western Railroad. This railway company is putting the new locomotive through actual performance tests.

In the field of metallurgical research, studies of super-strength alloys to withstand temperatures as high as 1250 deg. Fah. in steam boilers have produced five very promising compositions possessing long-time rupture strengths two to three times greater than that of the 18-8 stainless alloys, which are now the strongest superheater materials available.

With its long experience and background in the utilisation of fuels for steam generation and power production, it was natural for the Babcock and Wilcox Company to be among the pioneers in the development of atomic power. Because of its success in developing materials of construction, containing corrosive materials, fabricating and welding, and preventing radioactive leakage, the company has been chosen by the Consolidated Edison organisation to design, fabricate and erect the entire nuclear and steam-generating part of the first privately financed atomic power plant in the United States. Furthermore, Babcock and Wilcox will be the first American company to build a major private works for the production of fuel elements and other reactor core parts for commercial nuclear power reactors. A works of the firm now under construction at Lynchburg, Virginia, will soon be producing these fuel elements and reactor components. A significant recent advancement in the field of atomic energy made by the research centre is the development of a newly designed gasketed closure which prevents radioactive leakage from atomic reactors. An improvement over the solid weld, it eliminates the machine tool cutting and re-welding previously required to open and close atomic reactors.

The many additional accomplishments to come out of continued investigations at the research centre include : (1) welding equipment for a new automatic submerged-arc process that deposits metal five times faster than present automatic processes ; (2) steam purification equipment that is expected to solve the troublesome maintenance problem of preventing silica deposits in turbines ; (3) the improved manufacturing method for the ceramic fibre " Kaowool " which extends its range of usefulness.

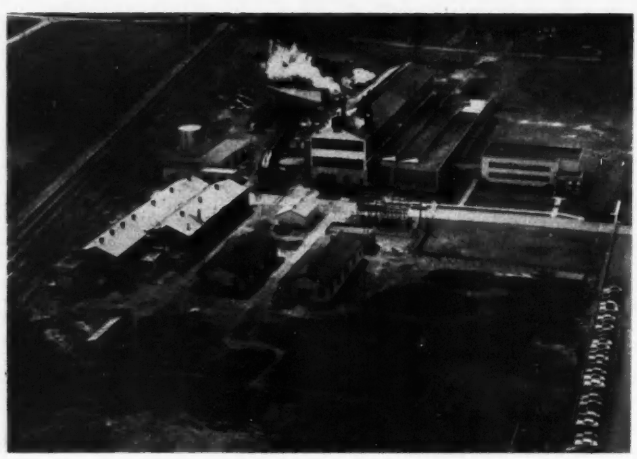


Fig. 1.—Aerial view of research centre at Alliance, Ohio

Organisation of Research Centre

Breaking the activities of the research centre down according to their functional divisions—materials development, product development, and technical service—the following are some of the major problems being studied.

Materials Development.—Testing and design problems in the fields of stress analysis, fluid flow and heat transfer are the main endeavours. Often special test apparatus and control instrumentation has to be designed by the research staff, necessitating developments in such fields as electronics. An alloy foundry casts and forges new alloys of special composition, which are then machined in the shop and tested for high temperature and pressure operation or for high and low temperature corrosion and creep rupture. New welding metals for use in the atomic field are being investigated and the design of welding equipment is constantly undergoing improvement. Data are gathered on the mechanical properties of metals at low and high temperature as well as information on strength, ductility, toughness, shock- and impact-resistance. Refractory research is concentrated on the development of efficient melting methods, on physical properties, especially at high temperatures, and on new applications. The chemical laboratory investigates the properties of fuels, steam contamination, corrosion of steel and ferrous alloys, the mechanism of corrosion on both the water and the steam side of boilers. It has developed extremely sensitive methods for analysing both feed water and steam, including the use of the radioactive tracer technique.

Product Development.—As a result of its fundamental investigation of steam generation at above and below critical temperatures and pressures, Babcock and Wilcox has been able to improve boiler design and develop its universal pressure unit. Other important new equipment being developed includes the cyclone furnace for finely pulverised solid fuels, the oil burning cyclone furnace package steam generators, separately fired superheaters, steam washers, pressure vessels, and towers and digestors for heat recovery and recovery of chemicals from black liquor in pulp and paper mills. Means are being sought for the efficient burning of the American petroleum industry's various low-volatile by-product and residual cokes. Boiler-cleaning methods, based on soot blowers, shot cleaning and tube vibration, are being refined. The problems of fouling and corrosion in air heaters are being investigated. Methods for pulverising coal are undergoing study, and the process of coal gasification is being explored.

Technical Services.—This section of the research centre is responsible for the background research and feasibility studies for many engineering projects, the design of pilot plant equipment and special test apparatus, and the providing of specialists in heat transfer, fluid flow, thermodynamics, mathematics and process and equipment design to act as consultants. It contributes to the study and evaluation of new power cycles, makes fundamental knowledge readily available to other technical groups in the company, and acts as a clearing house for the exchange of basic engineering information. In the field of heat transfer, the analytical engineering group has been co-ordinating the joint Babcock and Wilcox–Cornell experi-

mental study of cross flow convection heat transfer at Cornell University.

Although most of the company's investigations are now being carried on at Alliance, it also maintains research facilities at each of its manufacturing divisions. Thus, the works of the tubular products division at Beaver Falls, Pennsylvania, has a new laboratory with equipment for inspection and testing procedures as well as for the development of new alloys; the company's laboratory at Augusta, Georgia, conducts development work on insulating and refractory materials, and the works of the boiler division at Barberton, Ohio, has a laboratory for investigating many subjects having to do with the theory and application of fabricating processes.

Research Facilities

Atomic Energy.—Both high-pressure water-cooled reactor systems and liquid-metal-cooled reactor systems are at present being investigated by the company. In the field of water-cooled systems, studies are being conducted on heat transfer, the corrosion of various stainless "structural" alloys and the corrosion of fuel element cladding materials. Carbon steel and

Fig. 2.—Atomic energy test area at the Babcock and Wilcox research centre

other economically available materials of construction are being investigated with regard to their possible use in commercial power reactor plants. Methods have been developed at the laboratory for the analyses of carbon and oxygen in sodium and sodium-potassium alloys. Other projects being conducted at present include proof tests for proposed heat exchangers, pressure vessel stress studies, closure tests, material tests, and thermal shock tests.

Engineering Physics Section.—This section is concerned with testing and design problems in the fields of electronics, stress analysis, fluid flow and heat transfer. The electronics section designs and constructs many special instruments and controls for use by other divisions of the research centre. The stress analysis and design group measures stresses in pressure vessels and currently is conducting tests for stress rupture, creep, fatigue resistance and resistance to stress corrosion. During the development of the firm's 5500 lb per square inch super-critical pressure boiler, this group was called upon to determine stresses in the headers at pressures up to 30,000 lb per square inch. The fluid-flow and heat-transfer group is developing devices for separating steam and water, and for removing boiler water solids, such as silica, from steam. It is also studying flow distributions and the pressure drop calibration of steam equipment.

Alloy Foundry.—To help in its development of new boiler plants for high-temperature and pressure operation, a co-ordinated programme for melting, casting, forging and machining new metals and alloys has been developed at the research centre. Experimental alloys are being prepared and tested for high and low-temperature corrosion and creep rupture. In one programme extending over a two-year period more than 245 different alloys were prepared and thousands of hours spent in testing. This work resulted in the development of only five usable new alloys, but they were considered important in helping to develop new or better equipment. The foundry has up-to-date melting, casting, forging and heat-treating equipment. Four induction furnaces, powered by a 50kW, 3000 c/s motor generator set, make it possible to produce melts weighing from 10 lb to 140 lb. Ingots are forged on a 2500 lb steam hammer and a smaller air-operated one. Facilities for preparing and testing sand moulds are also situated in this area. Standards for the spectrographic testing of alloys are now being set up and, when completed, are expected to be the most comprehensive in existence.

Welding Building.—Welding equipment for a new automatic submerged arc process that deposits metal five times faster than present automatic welding processes is at present undergoing test and development in this section. New welding metals for use in the atomic field are also being investigated, and the design of certain welding equipment is undergoing improvement. Metal-joining equipment on hand includes submerged-melt automatic machines, atomic-hydrogen, inert-gas-protected metallic arc, as well as carbon-arc and oxy-acetylene cutting and welding units. Radiographic inspection is being used to determine the soundness of welds. For welds less than 2in thick, a 250kW X-ray machine is used, and for heavier sections the radioactive isotope Cobalt-60. Other non-destructive tests are performed by fluorescent penetrant, magnetic powder and ultrasonic equipment. A wire drawing bench is being used to develop unusual welding electrode alloys.

Creep Laboratory.—Work is being conducted here in testing new alloys for use in tubes for superheaters, and ultimately developing tubes for use at higher temperatures and pressures than are possible to-day. This section is believed to be the largest creep laboratory in the world. It is completely air-conditioned and comprises 136 lever machines for determining creep strength and rupture strength of materials after long periods at high temperatures. New alloys tested here have been accepted for critical work by the U.S. Air Force, and have helped to advance the temperature and pressure-operating limits in boilers. Materials are being developed to lengthen the service life of such critical equipment as high-temperature, high-pressure superheaters. The objective here is not only to develop new alloys, but to improve the performance of less costly alloys so that it will be unnecessary to use the more expensive alloys in reaching higher temperatures and pressures.

Metallurgical Section.—Data on the mechanical properties of metals at low and high temperatures, besides information on strength, ductility, toughness and shock and impact resistance, is being gathered here. The section comprises facilities for preparing, heat-treating, micro-polishing, micro-examining and determining the expansion behaviour of alloys. The furnaces used can heat-treat alloys at such extremely high temperatures as 2350 deg. Fah. for short periods and at the more usual service temperatures in the neighbourhood of 1850 deg. Fah. for longer periods. Micro-structures of metals are investigated at magnifications up to $\times 2500$.

Chemical Laboratory.—The fifty employees in the chemical laboratory comprise the largest research group. They handle all chemical problems arising within the company, and in addition perform service functions for other departments and for customers of the firm. Steam from virtually all equipment is tested here to determine its content of various contaminants. In the spectrograph room rapid and accurate determinations are made and recorded of the elements present in steel, fuel ash, water scales, refractories and other materials. Crystal structure is being studied with microscopes and two X-ray diffraction instruments. Water chemistry is considered to be of great importance in the successful operation of steam boiler plants, and special research on this problem goes on constantly. In addition daily control samples of water from research boilers are tested.

The corrosion of steel and ferrous alloys by water saturated with oxygen or by combustion gases containing sulphur compounds is a serious problem. The mechanism of corrosion on both the water side and the fuel side of boilers is always under investigation in the chemical laboratory and corrosion problems of the pulp and paper industry are also dealt with. Still another phase of the chemical laboratory's work is fuels research. Values of all types of fuels except gas are determined here and the constituents of coal and oil are investigated. A high-temperature viscometer measures the viscosity of coal ash at temperatures up to 2800 deg. Fah. The coal laboratory has been placed at a different level to avoid the contamination of other laboratories by dust when grinding coal samples.

Steam Generation Research Station.—(*a*) Below-Critical Steam Studies. In a special closed-loop pilot unit, experiments are being conducted that are expected to lead to the optimum arrangement of tubes in a boiler. Steam can be generated, separated from water, condensed, and circulated under close control in this unit. Water velocity, heat input rate, angle of tube inclination, feedwater treatment and volume percentage of steam can all be regulated to obtain any combination required. (*b*) Above-Critical Steam Studies. Data on the behaviour of steam at pressures up to 5000 lb per square inch is being gathered in this small pilot plant, which comprises a single-tube steam generator with a separately fired superheater. It is fully equipped with controls, and has apparatus for the sampling and analysis of feedwater. In this unit, pressure drop, heat transfer and feedwater characteristics are being studied. Results of tests made here are being embodied in the design of the new Philo station of the American Gas and Electric Company. (*c*) Model Test Station: Studies conducted on the models at this station led to the recommendation of a furnace design for the universal pressure boiler. A $\frac{1}{4}$ scale gas-fired model is being used to determine the best furnace arrangement for early thorough mixing of large quantities of re-circulated gas with the products of combustion. It is also used to study the distribution of flow of the mixture into a high duty convection surface. Open channel $\frac{1}{96}$ scale hydraulic table models represent-

ing a section of the furnace width are being used to observe the flow patterns obtained with various configurations.

Cyclone Furnace Station.—Solutions to the problems of effectively burning petroleum coke and other low-grade fuels are being sought here. To overcome the nuisance of fly ash and to facilitate the efficient burning of low-grade fuels high in ash, this section is experimentally burning different grades of coal, coke breeze, petroleum coke, anthracite, lignite and oat hulls in a 5ft cyclone furnace. This small completely water-cooled unit is being used for exploratory research to improve the overall design and find new applications for cyclone burners. Fuel particles are held within the cyclone by centrifugal force induced by pre-heated combustion air entering the cyclone at over 200 m.p.h. This causes extremely rapid burning at flame temperatures approaching 3200 deg. Fah. The residual carbon-free ash melts and flows into a slag tank where it is quenched with water. In this way, about 95 per cent of the ash from the burning fuel is collected within the cyclone furnace, resulting in a very clean exit gas. Under full load, this 5ft cyclone burns six tons of coal per hour.

Cyclone Furnace Development

Petroleum coke, resulting from a recently developed fluidised coking process, is becoming increasingly important as a potential source of low cost-fuel for industrial use in the United States, and tests have indicated that the cyclone furnace will provide a means for cheaply and efficiently burning this low-volatile, low-grindability material. The research centre is therefore engaged in an extensive test programme employing a 5ft diameter cyclone furnace to develop the most satisfactory arrangement for firing this special fuel. The importance of petroleum coke as an industrial fuel began with the recent development of the fluidised coking process by the Standard Oil Company of New Jersey. This process increases the yield of the lighter, more valuable hydro-carbon constituents, and produces petroleum coke in place of residual oil. This development in the petroleum industry will, in the not too distant future, tend to reduce residual oil in the American fuel market and substitute petroleum coke in its stead. This probable development makes it desirable for the owners of power stations now burning residual oil to install furnaces which can be readily converted to firing solid fuel, whether coal, petroleum coke or char. It is believed that petroleum coke will become increasingly plentiful. However, it may have a volatile content as low as 4 per cent, making it difficult to burn. This aspect of the fuel together with its low grindability makes it undesirable for conventional fuel burning equipment.

Fig. 3.—Lever machines in creep and stress rupture laboratory at research centre

Prior to the receipt of sufficient coke for conducting firing tests, preliminary studies were made at the research centre, burning other available low-volatile fuels such as anthracite coal, coal chars and coke breeze. At the same time extensive chemical laboratory studies were made on ignition temperatures, reactivity and ash characteristics of the fluidised coke. Based on these studies and on design aspects at present employed by the Deutsche Babcock and Wilcox Gesellschaft, modifications were made to the standard cyclone furnace. This modified furnace has now been found to burn lower-volatile fuel than was previously believed possible. Combustion rates as high as 800,000 B.Th.U. per hour per cubic foot of fuel were achieved with fuels having a volatile content of only 4 to 7 per cent. It is now felt that with this cyclone fuel consumers will be able to utilise low-cost, low-grade fuel supplies that are near at hand, instead of importing expensive high-grade fuels over long distances. The many petroleum refineries on the west coast of the United States are, therefore, particularly interested in the new furnace.

The 5ft diameter cyclone furnace at the research centre is shown diagrammatically in Fig. 4. It is of steel plate rather than tubular construction in order to facilitate the many and frequent changes in design details necessitated by research work. The unit is operated under atmospheric pressure on the water side, the cyclone, secondary furnace, and tube bank constituting three separate and distinct circuits with three corresponding sections of the steam and water drum, so that the heat absorption in these three sections can be individually determined with accuracy. The air heater is of alloy steel construction and is designed to heat the air to 1000 deg. Fah. at full load, but is arranged with by-pass and tempering means to give any desired air temperature at the cyclone. The bunkers are arranged to have multiple fuels available for ready change-over, if desired, and the slag tank is arranged to facilitate continuous removal of the quenched slag. During testing work the necessary thermocouples, probes, gas analysers, oxygen recorders, fly ash measuring apparatus, and the like, are installed to meet the requirements of any particular test.

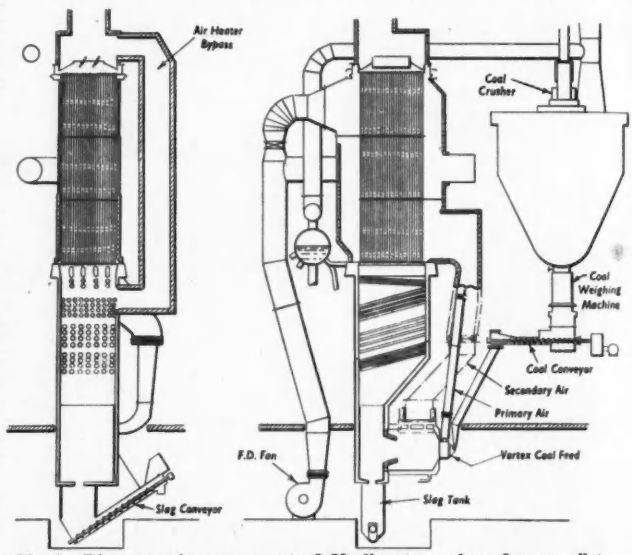


Fig. 4.—Diagrammatic arrangement of 5ft diameter cyclone furnace pilot plant at research centre

While this 5ft cyclone is well-suited for checking design and for fuel evaluation, it frequently happens that there is not a sufficient quantity of the fuel being investigated available to allow a run of reasonable length. The laboratory then resorts to a 2ft diameter cyclone having an appropriate capacity for the smaller and more preliminary tests. It consists of a refractory-lined, water-cooled furnace with a water-cooled throat with means to temper the combustion gases before they pass to an alloy steel tubular air heater designed to heat the combustion air to 1000 deg. Fah. With respect to the current investigation of petroleum coke, a number of tests were run on this 2ft cyclone, and it was determined that, provided there was an adequate amount of ash of a sufficiently low fusing temperature to ensure a continuously wetted inner surface of the cyclone, the coke could be burned satisfactorily with a low carbon loss, although it was somewhat greater than that when burning bituminous coal under analogous conditions. As larger supplies of this coke have now become available, the company expects to follow these preliminary tests with larger tests of longer duration on the 5ft cyclone installation. As part of its research work on cyclone furnaces, the firm has also installed a 5ft diameter cyclone at the Barberton Works to supply local steam requirements, and this unit is used for final tests of modifications before adopting developments for general commercial application. This unit is designed for a capacity of 70,000 lb of steam per hour at 165 lb per square inch gauge saturated.

Oil Burning Studies

While the primary fuel for power generation in America to-day is coal, there are places where either natural gas or oil are becoming more economical to use. Gas, of course, approaches the perfect fuel and presents few major problems, but the types of residual oils available for power generation do present problems, particularly as far as their ash quantities and constituents are concerned. Incidentally, in this connection, it is becoming quite apparent that the progress being made in the petroleum industry in the development of coking processes, which increase the yields of the lighter, more valuable constituents and produce the type of coke previously discussed in place of residual oil, will, in the not too distant future, tend to remove residual oil from the American fuel market and substitute the coke in its stead. In the burning of residual oils, the spray characteristics of the oil atomiser are considered to be of great importance. New designs of atomisers are carefully checked in the spray chamber at the research centre in which water is sprayed in place of oil and, based on experience, the results from the water tests can be correlated with the performance with oil. Droplet sizes, spray characteristics, and the like, are thoroughly investigated with this apparatus. The atomisers are then tested with oil under actual combustion conditions in a 12ft diameter, water-cooled oil-burner tunnel. In addition to the development of burner designs and the testing of combustion conditions, the effect of combustion and the use of additives on the $SO_3 : SO_2$ conditions of the resultant stack gases and, in turn, on the corrosive effects of these gases, is being studied in detail and interesting results are being obtained. Similar investigations predicated on this work are also being conducted in the field.

The desirability of being able to convert readily from oil to solid fuel has led the company to investigate the adaptability of the cyclone furnace to oil firing. If the cyclone can burn oil satisfactorily, then it could be installed for initial operation on oil with the assurance of

satisfactory conversion to solid fuel that would not be present with a standard oil-burning furnace. To determine this properly, the laboratory built a 5ft diameter cyclone on the 12ft diameter oil burner tunnel just mentioned. It was possible to prove very conclusively from this work that the furnace can burn oil satisfactorily in amounts to equal the maximum B.Th.U. release with coal, with a static pressure requirement of 8in of water and a load range of 10 to 1, which is equivalent performance to normal American oil-burning furnaces. If and when the time arrives that it would be economical to switch such a unit from oil to solid fuel firing, this could be done by removing the oil burner and register and installing the coal feed in its place. A higher static air blower would be required to meet the needs of the coal-fired cyclone. The only change to the pressure parts of the entire unit, however, would be the replacement of the cyclone furnace re-entrant throat with one of smaller diameter, by cutting out four small sections of tube and rewelding in their places four other tubes bent to the right shape.

Flow of Gases

An important aspect of the problem of heat absorption is the flow of gases through furnaces and its effects on the temperature equalisation of gases. On completed units in operation the company makes temperature traverses and plots isotherms so determined to depict graphically the conditions as they actually obtain in furnaces of a given design. This is extremely interesting and informative, but it is obviously of greater importance to know how to design new furnaces so that when the temperature traverses are taken on the completed unit in operation, the results obtained will be as desired. To obtain information on which to predicate design factors, the research centre makes use of water tables to study the furnace flow patterns. Plastic strips are used to conform with the furnace outline, and the water flow in the direction of gas flow, with dyes added, gives a qualitative, two-dimensional impression of gas mixing. This is particularly useful in the case of a furnace using recirculated gas for temperature regulation or the like, as differently coloured dyes, representing the main stream of combustion gases and the recirculated gases, show very vividly the conditions that will prevail in the furnace on mixing. However, this is not always adequate, and in some instances, where new designs of major importance are involved, the laboratory will follow this work with a three-dimensional one-sixth scale model in which natural gas is burned to obtain the primary combustion gases and, if gas recirculation is involved, air at room temperature is used to simulate the recirculated gas flow conditions determined by thermo-couples and pitot tubes.

(To be concluded)

Improved Bottom-Dump Scows

Ease of operation in congested areas around marine construction and dredging jobs is the most valuable property of two new bottom-dump scows which were recently completed by the Dravo Corporation of Pittsburgh, Pennsylvania, for the Great Lakes Dredge and Dock Company. Although capable of transporting 1500 cubic yards of high-density material, the new scows are 40ft shorter than previous vessels having the same capacity. It is expected that their shorter length will make the scows easier to manœuvre at the site of river, lake and harbour construction schemes, where dredges, derrick boats and other floating equipment are working.

The new vessel is illustrated in Fig. 1 and is 186ft long, 43ft wide and 16ft deep. Its hold is divided into eight hopper compartments, and bottom doors have been arranged so that each compartment may be opened individually. Each half of the double doors swings downward on hinges and fits flush against the side walls of the hull tunnel. The tunnel walls slope outboard so that the doors, in effect, are recessed safely away from the impact of falling rock and other material. Each door is 5ft 4in wide and approximately 18ft long, and is fabricated of heavy steel plate and beams. Replaceable timbers are installed as bumpers for the main contact points on the doors. When the double doors of each hopper compartment are opened, they provide about 8ft 6in of clear space for the cargo to drop through.

The operation of the hopper doors is a critical mechanical factor on dump scows. The machinery used must be rugged to support the heavy doors and their loads, and to withstand the impact of rock and other dredged material. The customary American method of door operation on dump scows involves the use of heavy chains and cables fastened to each door half. The chain is wrapped around a shaft to which a wire rope drum and a ratchet are attached. The doors are closed by pulling the wire rope off the drum with a winch. This turns the shaft and winds the door chain around it. A pawl is then inserted in the ratchet to keep the shaft stationary. A member of the crew opening the doors of an ordinary dump scow is subject to two hazards. First, he must use a sledge hammer to knock the pawl out of the ratchet. This may throw him off balance or cause his clothing to be caught in the spinning ratchet. Secondly, the wire rope which was pulled off the closing drum rapidly rewinds on the reel and whips and lashes dangerously around the deck. To overcome these hazards on the new dump scows, the builders designed an interesting mechanical device incorporating the use of a lever to release the pawl from the ratchet. As shown in Fig. 2, the release lever is interlocked with a jaw clutch for the closing drum, so that the drum automatically and simultaneously disengages from the spinning shaft as the doors drop open. The arrangement also eliminates the need for using a sledge hammer. The pawl, on the opposite side of the ratchet from the operator, is hinged so that it is drawn back away from the ratchet as the lever is moved.

Settlement of Plutonium Process Patent Claim

The U.S. Atomic Energy Commission has approved the payment of 400,000 dollars to four atomic scientists for the acquisition of all rights, title and interest in certain inventions in plutonium separative processes developed prior to their engaging in research work in connection with Government contracts. All rights in the pending classified patent applications on the inventions have been assigned to the Commission. The scientists are Dr. Glenn T. Seaborg, Dr. Joseph W. Kennedy, Dr. Arthur C. Wahl and Dr. Emilio G. Segre. In late 1940 and early 1941, they were associated with the University of California, where Drs. Seaborg and Kennedy were instructors in chemistry, Dr. Wahl was a teaching assistant, and Dr. Segre was a research associate. During this period, they made inventions and discoveries pertaining to the element plutonium and certain of its isotopes, in particular plutonium-239 and its neutron fissionability as well as certain aspects of its chemical properties. Their work included the discovery that plutonium in its lower oxidation state is carried from solution by certain precipitates, whereas in the higher oxidation state it is not carried. Subsequently, the four scientists were engaged in work under the Office of Scientific Research and Development and the "Manhattan District," or one of its contractors, and made valuable contributions as well as a considerable number of other inventions in the fields of chemistry and physics.

The early inventions and discoveries became the subject matter of classified patent applications filed by the scientists between 1945 and 1947. Pursuant to the Atomic Energy Act, which gave inventors rights to make application for awards in certain fields of subject matter, they filed an application for award before the Patent Compensation Board of the Commission in January 1950. The application was amended in December 1953. A stipulation settling the proceeding was entered into by the Commission and the four applicants, providing for the assignment of the subject matter of the inventions and discoveries to the U.S. Government, as represented by the Commission, and for the release of any and all claims that the applicants have against the Government by virtue of the inventions and discoveries.

Fig. 1—Bottom-dump scow with eight hopper compartments

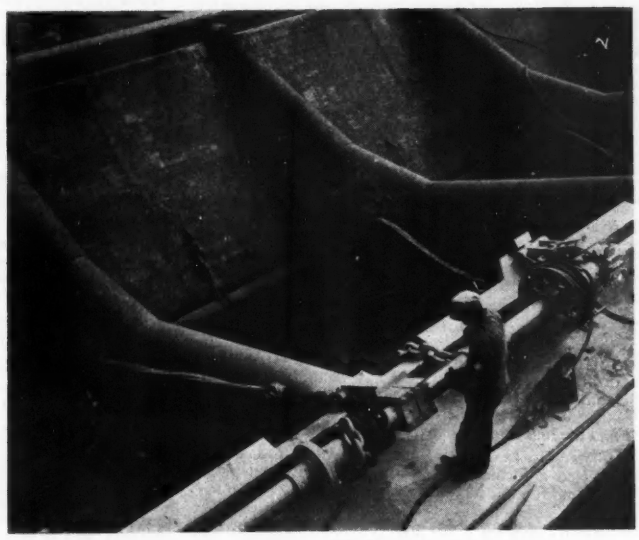


Fig. 2—Mechanism employed to control operation of hopper doors

Personal and Business

Appointments

BRIGADIER F. C. WALLACE has joined the board of Decca Radar (Canada), Ltd.

MR. H. J. WHITEHEAD has been appointed sales manager of John Ingham and Sons, Ltd., Middlestown, Wakefield.

MR. C. E. G. BAILEY, M.I.E.E., has been appointed technical director of Solartron Electronic Business Machines, Ltd., Thames Ditton, Surrey.

METROPOLITAN-VICKERS ELECTRICAL EXPORT COMPANY, Ltd., announces the appointment of Mr. E. C. Whiteley as manager, Middle East division.

MR. THOMAS G. ELLISON has been appointed chairman of George Ellison, Ltd., Tufnol, Ltd., and Alfred Ellison, Ltd., in succession to the late Mr. George Ellison, his father.

THE BRITISH INDIA STEAM NAVIGATION COMPANY, Ltd., announces the appointment of Mr. Walter Meech as commodore chief engineer officer of its fleet. He succeeds Mr. W. Johnson, who is retiring.

HAMWORTHY ENGINEERING, Ltd., Poole, Dorset, announces the appointment of Mr. Robert Atkinson, A.M.I.Mech.E., as director and general manager, pump and compressor division. He was formerly director and general manager of Hamworthy (B.C.E.), Ltd. Mr. L. C. Baker, M.I.Mech.E., has been appointed general manager of the latter company.

Business Announcements

Q.V.F., Ltd., Mill Street, Stone, Staffs, states that its telegraphic address is "Glassplant, Stone."

SUNVIC CONTROLS, Ltd., Eastern Industrial Estate, Harlow, Essex, states that its telephone number is Harlow 25271.

C. H. JOHNSON (MACHINERY), Ltd., Stockport, has been appointed sole selling agent in Great Britain and Northern Ireland for "Peiner" tower cranes.

WICKMAN, Ltd., Tile Hill, Coventry, states that, on September 1st, it will assume the sole agency for the products of Arthur Scrivener, Ltd., Tyburn Road, Birmingham.

METAL INDUSTRIES, Ltd., Universal House, 60, Buckingham Palace Road, London, S.W.1, states that its telephone numbers are now Sloane 7192, 5814 and 5618.

THE ATLAS DIESEL COMPANY, Ltd., Wembley, has moved its Bristol branch to 47A, Zetland Road, Bristol, 6 (telephone, Bristol 45036). Mr. W. J. Clarke is the branch manager.

THE B.S.A. COMPANY, Ltd., has purchased, for its subsidiary, The Daimler Company, Ltd., the controlling interest in Hobbs Transmission, Ltd., 78, Russell Terrace, Leamington Spa.

HEENAN AND FROUDE, Ltd., states that its name is being changed to Heenan Group, Ltd., which will be a holding company. Heenan and Froude, Ltd., is to be re-registered as a subsidiary entirely devoted to manufacturing activities.

IGRANIC ELECTRIC COMPANY, Ltd., states that Alan Colless Pty., Ltd., has appointed Clark-Strickland Pty., Ltd., 17, McKillop Street, Melbourne, C.1, Australia, as agent for Igranic motor control gear in the State of Victoria.

YOUNGS (LIFTING APPLIANCES), Ltd., Ryland Street Works, Birmingham, 16, states that it is now represented in London and the Home Counties by Oswald Record and Co., Ltd., 17, Victoria Street, S.W.1 (telephone, Abbey 2908).

INDUSTRIA (BEARINGS), Ltd., 115, Gunnersbury Avenue, London, W.5, states that it is now the accredited selling organisation in Great Britain for "F.J.G." ball and roller bearings manufactured by Frankenjura Industrie G.m.b.H., Erlangen.

Contracts

THE LOEWY ENGINEERING COMPANY, Ltd., Wallisdown Road, Bournemouth, has secured an order from the Ilva Steel Works for a continuous medium strip mill. The value of the order is over £500,000 and the mill is to be delivered by the end of next year.

THE GENERAL ELECTRIC COMPANY, Ltd., has received a further contract for pumpless steel tank rectifiers for the expansion of the electrified sections of the Netherlands Railways. The order covers nine 1224kW, 1500V, twin-cylinder units fitted with electronic arc suppression equipment.

HORSELEY BRIDGE AND THOMAS PIGGOTT, Ltd., Tipton, Staffs, has received a contract, for the construction of a river bridge, from the Department of Main Roads, New South Wales. The bridge, 716ft long by 40ft wide, is to span the Karuah River on the Shires of Stroud and Port Stephens State Highway No. 10. The value of the contract is given as £A71,800.

Miscellanea

NATURAL GAS.—The D'Arcy Exploration Company is to sink a second well near Crowborough, Sussex, as part of the Gas Council's search for natural gas.

MOTOR VEHICLE WORKSHOPS.—Lord Brabazon opened the new motor vehicle workshops which the National Benzole Company, Ltd., has built at Seacroft, Leeds. The site occupies four acres and the building has a floor space of 35,000 square feet.

INSHORE MINESWEEPERS.—The Inshore minesweeper H.M.S. "Riplingham" has completed acceptance trials and a sister ship, H.M.S. "Shipham," has been launched. Both vessels, which have a length of 106ft 5in by 20ft 6in beam, have been built by Brooke Marine, Ltd.

CHEMICALS FROM PETROLEUM.—British Petroleum Chemicals, Ltd., has ordered new plants which will double its "make" of olefines and diversify its list of petroleum chemical products. One unit will extract butadiene, for the manufacture of synthetic rubber and plastics and another unit will produce a polymer of propylene by catalytic means. Some of the polymer will form the feedstock for a plant, being erected for Grange Chemicals, Ltd., producing a detergent alkylate for the soap industry.

LIGHTWEIGHT FLEXIBLE AIR HOSE.—It is announced by Compoflex Company, Ltd., 26, Grosvenor Gardens, S.W.1, that it has introduced, originally to meet the requirements of the Rolls-Royce "Silver Cloud," an air-cleaner-to-carburettor hose more flexible and much lighter than previous patterns by virtue of the fact that the body thickness is considerably less than the thickness at the ends. The wall thickness at the ends, to provide easy and positive sealing, is 0·2in on a 2¼in hose, and with a thickness of 0·1in, including wire stiffening, at the centre portion a 15in length weighs only 9½ oz.

FUME CABINET FOR RADIOACTIVE COMPOUNDS.—A fume-control cabinet introduced by Turner and Brown, Ltd., Bolton, Lancs, in conjunction with Cygnet Joinery, Ltd., is designed primarily to handle radioactive compounds, being lined with lead and faced throughout with vinyl plastic. A fan, also plastic, draws air in through the electrically opened sash of armoured glass and delivers it to a water scrubber, supplied also with neutralising agents, and thence to a mist eliminator, so that the exhaust gases are virtually non-toxic. The cupboards are available in a range from 3ft standard units to 15ft composite units.

AERODROME ACTIVITY IN MAY.—Figures prepared by the Ministry of Transport and Civil Aviation for May, 1955, show an all-round increase in air transport movements and traffic at aerodromes over May, 1954. The increase is over 50 per cent at London Airport, due largely to the closing of Northolt, but the number of passengers was 20 per cent greater than at both airports together last year. The same increase appeared in the total for the United Kingdom, while freight, at 10,320 short tons, was 34 per cent higher. Of this tonnage 4290 tons passed through Ferryfield, the aerodrome specialising on flights across the English Channel, and 3190 tons through London. Aircraft movements rose by 12 per cent overall.

HIGH-SPEED RESEARCH AIRCRAFT.—The United States Air Force has announced that the Bell "X–2" research aircraft is now ready for flight. Just as the "X–1" pioneered speeds of the order of 1000 m.p.h., this aircraft is designed to encounter the problems of flight at 2000 m.p.h. At this speed at low altitudes, the temperature of the aircraft would rise to about 450 deg. Fah., and consequently aluminium alloys are discarded in favour of stainless steel; much interest is shown in titanium alloys for these duties. The windscreen of the "X–2" is of a tempered glass able to withstand 1000 deg. Fah. The aircraft is driven by a Curtiss-Wright rocket motor of an estimated 16,000 lb thrust. Like the "X–1" it is purely a research aircraft.

PILOT LAUNCH.—An order for an experimental fast pilot launch has been placed with John I. Thornycroft and Co., Ltd., by the Corporation of Trinity House, London. Designed in co-operation between Trinity House and the builders, the launch will ship the pilot directly from the shore to the vessel, and will accommodate up to twelve pilots for short periods. Measuring 70ft overall, with a beam of 15ft, she will have a heavily fendered hull of double-skin mahogany. Twin Rolls-Royce C.8. S.F.L.M. diesel engines will be installed, giving a speed of 15 knots. The vessel will have twin screws and twin rudders and will be equipped with radar and both medium and very high frequency radio-telephone sets.

REFRACTORY CEMENT.—It is announced by the Lafarge Aluminous Cement Company, Ltd., 73, Brook Street, London, W.1, that supplies of "Secar 250" cement are now available in Great Britain. "Secar 250" is a white calcium aluminate hydraulic cement with an alumina content of 70 to 75 per cent and with total impurities less than 1 per cent. While setting time and ultra-rapid hardening of refractory concretes made with this cement are similar to those made with Ciment Fondu, their refractoriness is much increased. As an example, the maker quotes a concrete made with corundum aggregate which will sustain a cooking temperature of 1800 deg. Cent. All such concretes can be put into service within twenty-four hours of casting. They do not shrink and have a high resistance to thermal shock.

TECHNICAL DATA CHARTS.—We have received from Horace Priest Chemical Engineering Company, Ltd., "Beverley," Farthings Hill, Horsham, Sussex, the first four of a series of technical charts. The early numbers include nomograms giving the logarithmic mean temperature difference through a heat exchanger and the Reynolds number for flow through pipes, and tables for Centigrade/Fahrenheit conversions between 0 deg. Fah. and 1500 deg. Cent. Later charts will cover a wide range of subjects, including distillation, heat exchange, absorption, liquid and gas extraction, evaporators, general properties of chemicals, and mechanical design requirements. These charts will be supplied free of charge upon application to the firm at the above address.

SPRAYED ASBESTOS COATINGS.—A contracting department for carrying out asbestos spraying has been established by William Kenyon and Sons, Ltd., of Dukinfield. The firm employs a mixture of asbestos and other fibres to its own specification, known as "Asbestospray." The work is first treated with a rubber-based primer and the fibre is then sprayed on, using both water and compressed air through the medium of a specially designed gun. The field of application is claimed to be wide, practically all building materials being suitable, and the process being adaptable to the protection of exposed roof trusses and other steelwork. The chief value of the process, however, is claimed to be for heat and sound insulation, fire resistance and as an anti-condensation medium.

TRENCHER FOR LIGHT EXCAVATOR.—A trenching attachment has been added to the standard range of equipment used with the "Ahlman Swing Shovel" AII and III wheel-mounted excavators. The attachment comprises a back-acting hydraulically operated bucket, carried on a fabricated sheet metal jib assembly. The bucket may be 12in or 24in in width, the larger size having a capacity of 10 cubic feet. Trenches can be excavated to a depth of 5ft 6in, and the muck lifted clear to a height of about 6ft. The trencher is operated with the standard hydraulic controls used for the face shovel, through a simple mechanical linkage. The change-over from face shovel to trencher can be made in about fifteen minutes, it is claimed. The U.K. agents for the machine are Abelson and Co. (Engineers), Ltd., Coventry Road, Birmingham, 26.

TOWER PACKINGS.—"Tower Packings in Modern Chemical Engineering" is the title of a technical booklet recently issued by Weinreb and Randall Ltd., 70, New Oxford Street, London, W.C.1. In addition to Raschig rings and Berl saddles, the booklet discusses a wide variety of subjects, including, among others, the properties of the material for tower packings, together with relative data in tabular form; pressure drop; effect of broken or deformed packing rings; variation of efficiency with packed height; theoretical plate values; limiting velocities and pressure drops and the packings as catalyst carriers. There is a bibliography and an extensive list of references.

ULTRASONIC TESTING IN TORONTO.—Toronto's best-known hospital, the Toronto General, is undergoing a 20,000,000 dollars extension which will almost double its present facilities. About 2900 tons of steelwork will be required for the new buildings. The steelwork for this extension is being fabricated and erected by the Dominion Bridge Company's Ontario division. All steelwork is being completely shop and field welded, and the consulting engineers, Messrs. Wallace-Carruthers and Associates, have specified that ultrasonic testing be used, after experiments have been carried out by Canadian Inspection and Testing Company, Ltd. This application of ultrasonic testing to welded joints is believed to be the first of its kind in Canada. A portable apparatus manufactured by Kelvin-Hughes in Great Britain was selected as being most suited for working on open steelwork high above ground level.

MINERAL RESOURCES POLICY.—The Institution of Mining and Metallurgy is arranging a meeting to discuss a minerals policy for the United Kingdom, to take place on Thursday, September 22, 1955, at the Hall of the Royal Society of Arts. At this meeting members of the Institution and others concerned with the mineral resources of the British Commonwealth will be asked to consider whether some co-ordination of effort at every stage of production would be desirable, to conserve supplies or expand output to the best advantage, and to propose how such aims might best be achieved. The object of the symposium is to allow fuller discussion of the proposals contained in a paper entitled "Mineral Resources Strategy," by Mr. D. A. Oliver, C.B.E., director of the B.S.A. Group Research Centre. This paper was first submitted at a Conference on Research and Industrial Productivity held in London in November, 1954, organised by the Department of Scientific and Industrial Research in association with the British Productivity Council. The theme of Mr. Oliver's paper was "that minerals productivity will be increased if greater co-ordination of the right kind can be established between all the interested parties"—geologists, mineral dressing and mining specialists, mining and finance houses, mining engineers, local territorial authorities, fabricators and users, and, finally, Government.

British Patent Specifications

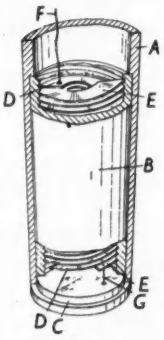
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2. 3s. each.

ELECTRICAL ENGINEERING

733,703. December 4, 1952.—ELECTRODE ARRANGEMENTS FOR CONDENSERS AND IONISATION CHAMBERS, The United Kingdom Atomic Energy Authority, London. (*Inventor: Percy George Salmon.*)

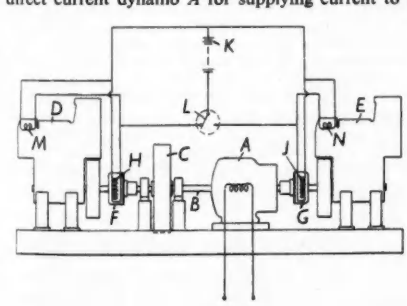
The invention relates to devices having electrodes spaced in close parallel relationship. Such a device constitutes a condenser and may be used as an air spaced or vacuum r.f. condenser or adapted to serve other purposes such as the electrode assembly of an ionisation chamber. The invention also provides a new form of fission chamber which is simple to construct and may be made to withstand high temperatures. The invention as applied to a fission chamber suitable for high temperature operation is illustrated in the drawing. The fission chamber comprises a metal tube *A* recessed at one end to receive a pyrophillite tube *B* retained by a metal cap *C*. The tube is 1½in long, ⅜in external diameter and ⅛in internal diameter having an internal two-start thread. Each thread has a pitch of $\frac{1}{16}$in and two electrodes *D* and *E*, each having twenty-four helical turns, are screwed into the two threads. The electrodes are formed from ⅛in diameter aluminium rod and coated with uranium oxide to a thickness of 1mg per square centimetre. Contact is made by leads *F* and *G*, spot-welded directly to the respective electrodes, the lead *G* being connected to the cap *C* and the lead *F* being taken through a glass-to-metal seal at the remote end (not shown) of the metal tube *A*. The tube is filled with argon to a pressure of 10 atmospheres. In an application of the invention to an ionisation type of neutron flux detector a similar construction to that of the example given may be employed except that a boron, instead of a fissile, coating is provided. For measuring neutron flux unaffected by the presence of gamma radiation one of the helical electrodes may be divided into two helical portions, threaded into the tube *B* from opposite ends, and one-half only provided with a boron coating. The uncoated half of the chamber will then respond only to gamma radiation and may be used to back-off the gamma response of the boron-coated neutron responsive half of the chamber.—*July* 20, 1955.



No. 733,703

733,739. June 15, 1953.—ELECTRIC POWER-GENERATING PLANT, Chance Brothers, Ltd., Glass Works, Smethwick, 40, Birmingham. (*Inventor: Louis Bertram Henry Hallett.*)

The invention relates to a power-generating plant of the kind comprising an engine and a dynamo. Its object is to ensure maintenance of the action of the dynamo in the event of engine failure. Referring to the drawing, there is provided an alternating or a direct current dynamo *A* for supplying current to a system for which it is essential to maintain continuity of power supply. On the rotor shaft *B* of the dynamo is mounted a heavy flywheel *C*. At each end of the rotor shaft is arranged an internal combustion engine *D* and *E*. For connecting the engines to the shaft a pair of electromagnetic or other automatic clutches *F* and *G* are provided. Also there are provided any convenient clutch-control means such that disconnection of either clutch is automatically accompanied by connection of the other clutch. The arrangement is such that the dynamo can be driven by either of the engines, and in the event of failure of the engine in action, the associated clutch is automatically disconnected and the other clutch is simultaneously rendered operative for connecting the other engine to the dynamo, the energy of the flywheel serving to start the second engine and drive the generator until the full power is available from the engine being started. Either engine can thus serve as a stand-by for maintaining the dynamo in action. If desired the control means can be adapted to effect periodic change-over of the engines. Any convenient means may be employed for controlling the action of the clutches *F* and *G* in response to movement derived from the engines. In the drawing, each clutch is of the electromagnetic type which includes an exciting winding *H* and *J*. Current can be supplied to either winding from a battery *K*, or other convenient source, under the control of an automatic two-way switch *L*, which is operable by any convenient and known mechanical or electrical means responsive to the speed of the engines or dynamo. Also there may be provided in association with each engine a solenoid *M* and *N* for controlling a fuel supply valve. By this invention it is claimed that the required maintenance of power supply from the dynamo can be ensured in a very simple manner.—*July* 20, 1955.

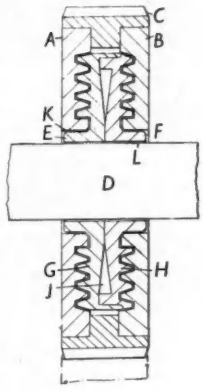


No. 733,739

POWER TRANSMISSION

733,590. March 25, 1953.—IMPROVED FRICTION CLUTCH, Thomas Hindmarch, Lindo Lodge, Stanley Avenue, Chesham, Buckinghamshire.

The object of the invention is to provide a pinion incorporating a friction clutch in which adequate concentricity is maintained when the clutch is in the disengaged condition. As will be seen from the drawing, the two outer clutch members *A* and *B* are connected by a toothed gear ring forming the pinion *C* by means of which a drive to or from the shaft *D* may be transmitted when the clutch is engaged. These clutch members are mounted for free rotation upon the cylindrical projections *E* and *F* upon the inner clutch members *G* and *H*. The inner clutch members are splined upon the shaft *D* by means of which they can move longitudinally of the shaft away from one another to contact the outer members *A* and *B* to transmit the drive when pressure fluid is introduced into the pressure cavity *J*. When the clutch is engaged the clearance shown at the point *K* has no effect as the outer members are located in relation to the inner members by V-grooves themselves, while the clearance at the point *L* can be made comparatively small and thus the gear runs true when the clutch is engaged. However, when using the outer member as an idler gear the clearance at the point *K* when added to that at the point *L* causes the gear to run eccentrically with consequent inaccurate engaging of the gear teeth, by reason of the fact that the gear member runs on the movable member which, in turn, has sliding clearance on the splines on the shaft. A modified design is also shown in the specification. In the form of construction as shown in the drawing, if the clearance at *K* were twenty-thousandths of an inch and the clearance at *L* twenty-thousandths of an inch, there might, under working conditions, be a variation in the depth of engagement of the gear teeth of forty-thousandths of an inch. The pinion constructed in accordance with the invention can be usefully employed in a constantly meshed form of change direction and/or change speed gearbox, particularly where the pinion transmits a drive between pinions on parallel shafts and acts as an idler when its clutch is disengaged. Under such a condition the pinion runs concentrically and its teeth are maintained at correct depth of engagement with other pinions.—*July* 13, 1955.

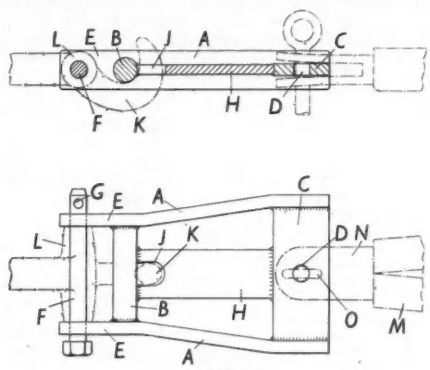


No. 733,590

AGRICULTURAL ENGINEERING

732,816. August 19, 1953.—DRAWBAR COUPLINGS FOR VEHICLES, John Clement Hitchcock, Chapel Farm, Ringshall, Stowmarket, Suffolk.

The invention relates to drawbar couplings for the attachment of trailers or wheeled implements to vehicles, such as agricultural tractors. As shown in the drawing, the auxiliary drawbar coupling comprises a pair of side members *A*, consisting of flat bars rigidly tied together near a front end by a transverse rod *B* and at the other or rear end by a transverse flat plate *C*. Preferably the side members are more widely spaced at the rear end than at the front end. Portions *E* of the side members extend forward of the transverse rod *B* and are drilled to receive a removable cross pin *F*, which can be held in place by a linch pin inserted in a hole *G*. A centrally disposed flat plate *H* extends between the rod *B* and the plate *C* and is welded to each of these parts. A slot *J* is formed in the forward end of the plate *H* adjacent the rod *B*. The arrangement is such that the auxiliary drawbar coupling can be secured to the drawbar hook of a Ferguson tractor having a hydraulic hitch assembly. Such drawbar hook is shown at *K* and has a pair of transverse extensions *L* bored to receive a transverse pin which normally receives a pair of arms forming part of the hydraulically operated hitch assembly whereby the drawbar hook can be raised and lowered. The transverse rod *B* of the auxiliary drawbar rests in the hook *K* and the end parts *E* are secured in the extensions *L* by the pin *F*. The auxiliary drawbar coupling can then be secured to a trailer or wheeled implement having a hitch beam *M* with a double lip or fork end *N*. The lips of the fork end of the hitch beam pass over and under the transverse plate *C* and are secured by a clevis pin *O* which passes through the holes in the lips *N* and through the hole *D* in the plate *C*. It will be obvious that a hitch beam having a fork or double lip end as shown cannot be directly secured to the tractor hook *K*. The arrangement of the auxiliary coupling in the tractor hook is such that it will remain more or less aligned with the hook drawbar when it is raised and lowered by the hydraulic hitch assembly, and it will be understood that links forming part of such assembly will normally be engaged by the transverse pin *E*, although not shown. However, if such hitch assembly is not employed the auxiliary coupling can still be used as shown, using either the existing pin or a similar additional pin.—*June* 29, 1955.

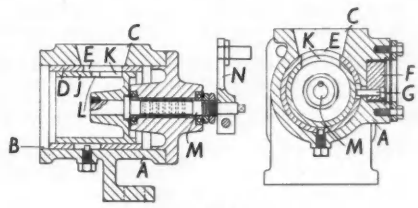


No. 732,816

INTERNAL COMBUSTION ENGINES

733,197. November 3, 1952.—GAS-REGULATING VALVE FOR GAS ENGINES, Belliss and Morcom, Ltd., Ledsam Street Works, Birmingham, 16. (*Inventor: Henry Edward Muckley.*)

The invention relates to a gas-regulating valve responsive to the action of a governor for use on a gas engine. Where the quality of the gas supplied to the engine is liable to considerable variation, or where it is required to be able to use different kinds or qualities of gas in the same engine, it is desirable to be able to vary the rate of flow of the gas by adjustable means additional to the means operable by the governor, so that a given governor-actuated means can operate satisfactorily with any gas. The object of the invention is to enable the requirements to be met in a simple and satisfactory manner. Referring to the drawing, there is provided a hollow body *A* having a cylindrical bore open at its outer end *B*. A gas inlet *C* is provided in one side of the body. Within the bore is contained an axially slidable bush *D*, and in the side of this bush is an inlet orifice *E*, situated adjacent to the inlet *C* in the body. The shape of the orifice *E* is such that by the axial movement of the bush, the effective area of the gas inlet can be

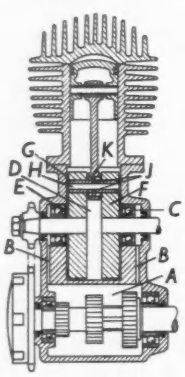


No. 733,197

varied to suit the gas to be used in the engine. In this case the orifice *E* is of square shape. Any convenient manually operated means can be provided for actuating the bush. As shown in the drawing, a crank disc *F* is rotatably mounted on the body, the disc having a laterally projecting pin *G*, engaging the bush *D*. The periphery of the disc has formed on it teeth which are engaged by a manually rotatable worm carried in the body. Within the bush is an angularly movable gas-regulating member *J* of hollow cylindrical form, this member being open at the outlet end, and having a lateral inlet orifice *K* situated adjacent to the orifice in the bush. The shape of this orifice may be of any convenient form. Thus, it may be in part of rectangular form, one edge *K* being bounded by a straight inclined edge. From the closed end of the regulating member *J* extends a spindle *M*, which, at its outer end, has secured to it an arm *N*, through which the required angular movements are imparted by the engine governor. The arrangement is such that the bush *D* is adjustable to suit the quality of gas to be used. Control of the gas flow in response to load variations is effected by the action of the governor. By the invention, the valve can be standardised for use on any engine controlled by a given governor, while to adapt the valve to suit any given gas it is merely necessary to effect an appropriate setting of the manually adjustable part.—*July* 6, 1955.

734,378. March 20, 1953.—LUBRICATION OF TWO-STROKE INTERNAL COMBUSTION ENGINES, Auto Union G.m.b.H., Schrannenstrasse 3, Ingolstadt/Donau, Germany.

The invention relates to two-stroke internal combustion engines, and in particular to those usually lubricated by oil which is added to and mixed with the fuel. The drawing shows a longitudinal central section through a single-cylinder two-stroke engine for a motor-cycle, with a unit construction

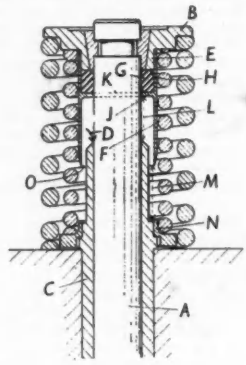


No. 734,378

change-speed gearbox and crankcase. The crankshaft bearings are each connected with the change-speed gearbox *A* by the conduit *B*. The gearbox *A* serves as a container for lubricating oil. Lubricating oil fog from the gearbox is sucked into the crankshaft bearings *C* through the conduit *B* by the reduced pressure produced in the crank case *D* during the upward movement of the piston on the crankcase induction stroke. An annular diaphragm *E* of thin sheet metal is mounted between the crankshaft bearing *C* and the disc crank *F* and serves as a non-return valve during the downward movement of the piston on the crankcase compression stroke. The diaphragm is attached along its inner border either to the disc crank or to the inner race of the ball bearings, its outer border moves resiliently in such a manner that it is lifted off its washer during the crankcase induction stroke and that it seals the conduit *B* against the crankshaft casing *D* during the compression stroke. In the left-hand part of the drawing is shown a channel *G* formed by an annular ridge on one of the disc cranks, which slopes in towards the crankshaft. This channel catches lubricating oil sucked in through the crankshaft bearings. This oil is thrown out by centrifugal force and flows through the hollow crank-pin *H* and the transverse lubricating bore *J* to the big-end bearing *K*.—*July* 27, 1955.

733,326. October 12, 1953.—SEALING DEVICES FOR POPPET VALVES, Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany.

The invention relates to sealing devices for poppet valves of internal combustion engines, the primary purpose of such devices being to prevent lubricant from passing along the valve stem out of the valve operation space into the passage conducting intake air or mixture or exhaust gas. The drawing shows the overhead valve of an internal combustion engine having a valve stem *A*, a valve spring abutment plate *B*, and a valve guide *C*. It is important to reduce to a minimum the amount of splashed lubricating oil entering between the valve stem *A* and valve guide *C* in the direction of the arrow *D*. For this purpose, the

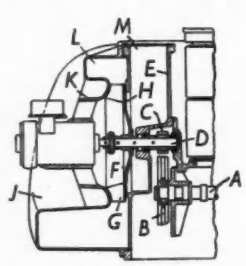


No. 733,326

valve spring abutment plate *B* is provided with a collar *E*, on to which the upper or securing part of a cover sleeve *F* is forced and soldered. The cover sleeve has susbtantially the same external diameter throughout, but has its lower end face externally chamfered at an acute angle, so as to force oil away from the guide on depression of the valve. The upper end face of the cover sleeve *F* is perpendicular to the axis of the valve, so as to assist in the soldering of the cover sleeve to the collar *E*. In addition, a sealing ring *G* is pressed against the lower surface *H* of the collar *E* by means of a transverse wall *J* of the cover sleeve *F*, and is thus held in position. The valve stem *A* passes through a central bore *K* in the transverse wall *J*. The lower or cover part of the cover sleeve *F* extends with clearance over the upper part or head of the valve guide *C*, and the lower edge of the cover part comes below the upper edge of the valve guide in the closed position of the valve. The distance *L* between the upper end of the valve guide *C* and the transverse wall *J* must be somewhat greater than the greatest possible stroke of the valve. Similarly, the distance *M* between the lower end of the cover sleeve *F* and the upper edge of a valve-securing plate *N* must also be greater than the greatest possible valve stroke. Thus, oil can only reach the valve stem through the very restricted annular opening *O*, both in the closed and open positions of the valve.—*July* 6, 1955.

733,949. March 26, 1953.—COOLING AIR BLOWERS FOR AIR-COOLED ENGINES, Ferdinand Porsche, responsible partner of the firm of Dr. Ing. h.c.F. Porsche Kommanditgesellschaft, Schwieberdinger Strasse 141, Stuttgart-Zuffenhausen, Germany, and Allgaier Werkzeugbau G.m.b.H., Uhingen/Wurttemberg, Germany.

The drawing shows a constructional example of the invention. A basic blower structure is provided with blades axially offset from its impeller body and which is driven by the camshaft *A* by means of



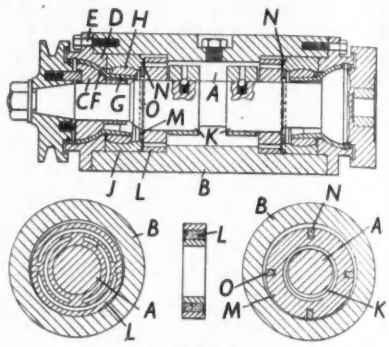
No. 733,949

gear wheels *B* and *C*. The gear *C* is coupled with the blower shaft *D*. The blower shaft is supported in an engine end plate *E*, which partitions the engine from the blower, by bearings. The impeller body supporting the blades *G* has on the side opposite the blades an annular shoulder *H* about in radial register with the inner root of the blades. The shaft with the impeller body on it rotates in an air-guiding casing *J* having an air inlet *K* on the side of the casing remote from the engine end plate and provided with air-guiding members. The casing also comprises a delivery conduit *L*. The engine end plate forms one wall of a conduit *M*, the opposite wall of which closes the side of the casing *L* remote from the air inlet. The arrangement consists of few easily manufactured parts, the blower being designed for the performance required. The same blower can, however, by the introduction of a few parts and without altering the original construction and the air conduction, be converted into a double blower suitable for greater air flows, for engines with, for instance, three to four cylinders. Such a blower is also shown in the specification.—*July* 20, 1955.

MACHINE TOOLS

734,103. May 7, 1953.—MACHINERY BEARINGS, Peter Phillimore Swatman, 87, Kineton Green Road, Olton, Birmingham.

The invention relates to machinery bearings of the kind required to support a rotary spindle within a stationary housing, or a rotary part on a stationary spindle, particularly in high precision machine tools or other mechanisms. As shown in the drawing, two bearings are employed for supporting a rotatable spindle *A* within a stationary housing *B*, the bearings being arranged at or adjacent to the ends of the



No. 734,103

housing. On the spindle is formed or secured a part *C* having an outer convex peripheral surface corresponding to a spherical zone having its largest diameter at one end of the part. For insertion in the housing is provided a flanged bush *D* which at one end has formed in it a concave surface complementary to that on the spindle, this bush being secured to the housing by screws *E*. The relative diameters of the two parts *C* and *D* are such as to provide between them a narrow annular space to be occupied by a hollow intermediate part. The intermediate part is shaped at one end *F* to fit the annular space, and the other projecting end *G* is shaped to a hollow cylindrical form. On the cylindrical end of the intermediate part is slidably and rotatably mounted a collar *H* corresponding to a surrounding spherical zone. The collar occupies an eccentric bore in a rotatable ring *J* which fits the inner surface of the housing the periphery of the eccentric bore being complementary to that of the collar *H* and the arrangement being such that rotation of the ring imparts a gyratory motion to the intermediate parts *F* and *G*. Rotation of the eccentrically bored ring may be effected in any convenient manner. Preferably it is rotated by a frictionally-operated epicyclic mechanism of the so-called "creep" type. In one form this comprises an eccentric *K* formed on the spindle and which occupies a bore in a ring *L* of rather less diameter than the adjacent internal diameter of the housing, the ring being arranged in rolling contact with the inner surface of the housing. The ring *L* is connected to the ring *J* by a coupling comprising a floating ring *M* which is notched for engagement with projections *N* and *O* on the rings *L* and *J* respectively, as shown in the left-hand view. To enable the ring *L* to maintain the required frictional contact with the housing, it is made resilient. In the example shown, the ring consists of a disc of nylon or other plastic material having formed in it segmental gaps extending across the width of the disc. Alternatively and as shown in the lower centre view, it may comprise a pair of concentric annular parts between which is bonded a ring *L* of rubber or rubber-like material, or the ring may be substituted by a spring. When the spindle *A* is rotated, the motion imparted to the intermediate members *F* and *G* has the effect of preventing localised wear of the spherical bearing surfaces by particles of grit which may be entrained in the lubricating oil, and also of maintaining the sphericity of the surfaces.—*July* 27, 1955.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Wed., Aug. 31*st., to Wed., Sept.* 7*th.*—Annual Meeting in Bristol.

ENGINEERING, MARINE AND WELDING EXHIBITION AND THE FOUNDRY TRADES EXHIBITION

Thurs., Sept. 1*st., to Thurs., Sept.* 15*th.*—Olympia, London. Open each weekday from 10 a.m. to 8 p.m.

INSTITUTE OF WELDING

Wed., Nov. 2*nd., to Fri., Nov.* 4*th.*—Autumn Meeting, London.